TURNER & GOLDSMITH'S

SANITATION IN INDIA

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IN ACKNOWLEDGMENT OF THE ASSISTANCE GIVEN BY THAT BODY TO THE PUBLIC HEALTH DEPARTMENT AND THE BOMBAY SANITARY ASSOCIATION TOWARDS PROMOTING THE EDUCATION OF THE PEOPLE IN SANITATION AND PUBLIC HEALTH.

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PREFACE TO THE FIRST EDITION.

DURING the past twelve years the Public Health Department of Bombay has, under the auspices of the Government of Bombay, been giving a six months' course of lectures with a view to making provision for a supply of men versed in the theory and practice of sanitation, for employment as Inspectors or Health Officers in mofussil Municipalities. Students come from all parts of India and Burma. At the end of the course an examination is held and certificates are awarded to successful students. Latterly the Royal Sanitary Institute, London, offered to co-operate in the examination and grant its certificates to successful candidates. The offer was accepted and this arrangement has been in force since 1910.

With a view to improving the sanitary condition of the country and securing the better observance of health regulations, the Government of India and the Provincial Governments have recently put in force a scheme for the improvement of the sanitary services and laid down rules for the guidance and instruction of students.

The lectures and demonstrations given to students of the Sanitary Surveyors' Class by the Officers of the Public Health Department, Bombay, have now been elaborated and published in the hope that they may reach a wider circle of students than can manage to attend the Class, and generally provide for Municipalities and others interested in questions of public health and hygiene a handy and practical guide to sanitation in India.

The book aims at providing the sanitary student with information on the practical application of modern sanitary methods adapted to India as well as to other places; for the principles of sanitation are the same in all countries although the conditions may differ.

As far as possible, each subject has been dealt with in a practical form, so that the book may furnish information which may be of value to the sanitary student in carrying out the duties of a responsible post.

It will be seen that the Public Health Acts and By-laws both in England and India have been given in full on each subject, because we lay great stress on the value of properly constructed laws and regulations for any scheme of sanitary progress in India. As pointed out in the Chapter on Administration, the Acts and By-laws in force in the various towns of India are based on the Public Health Act, 1875, and other English Acts, modified to suit the conditions, but are weak in many respects. The Sanitary Officer should realise the importance of a thorough acquaintance with the sanitary regulations in force in his district and be able to suggest amendments which are required from time to time.

We recognise that there is in the book much that relates to purely local sanitary methods of a large city like Bombay, but we make no excuse for this, for we hold that the highest standard should always be aimed at. All the towns and cities cannot work up to that standard at once. But though some towns and districts can only spend thousands while others spend lakhs, the principle involved is the same.

We do not claim to have covered the whole area of sanitation in India which is a very wide one, but we trust we have introduced some new matter not touched upon before. For contributions on some of the subjects the works of other authorities have been freely consulted. In the Chapter on Malaria the works of Manson, Ross, James, Liston and Bentley have been freely drawn upon, while it also includes a detailed statement of a Malaria campaign in a large city. Maxwell's book on "Refuse Disposal in England," Robertson and Porters' "Sanitary Law and Practice in

England" are among other standard works to which we have referred.

A special feature of the book is the insertion of a large number of photographs illustrative, as far as possible, of the sanitary methods dealt with.

Though some of the measures advocated cannot be immediately applied to all parts of India, it is hoped that the example set by the larger cities, which are enumerated in the book, will have the effect of stimulating interest in sanitary matters throughout India, and that many of the growing towns and cities will gradually recognise the importance of organising a trained staff of Sanitary Officials and of carrying out those measures which experience has shown to be both necessary and practicable.

I am deeply grateful to my assistants and staff generally for their valuable co-operation and help ; to Mr. N. S. Kowshik, the Chief Clerk of the Health Department, are due our warmest thanks for his assistance in correcting the proofs and to Mr. Shamrao G. Rajapurkar for many of the drawings. The co-operation of the *Times of India* Press has greatly facilitated the publication of this book.

BOMBAY, *January*, 1914. } J. A. TURNER, M.D., D.P.H.

PREFACE TO THE SECOND EDITION.

OWING to a continued demand for the book, since the first edition was exhausted towards the end of 1915, the publication of a second edition has become necessary.

The opportunity has been taken to carefully revise the book. Some of the chapters have been re-arranged; parts have been re-written; much new matter has been introduced; new illustrations have been inserted, a few of the old have been withdrawn; and an index has been added. Regulations and details necessary for a closer study of the subject have been given in smaller type.

Some valuable suggestions contained in the reviews which appeared on the publication of the book have been adopted. The original plan and object have, however, been steadily kept in view.

The work of revision, like that of compilation in the first instance, has had to be accomplished when circumstances permitted under conditions not favourable to constant attention, and a few omissions and typographical errors may still exist.

To Dr. Goldsmith and Mr. N. S. Kowshik and my assistants my thanks are due and I have much pleasure in associating their names with mine in the publication of the book, which, we trust, may prove increasingly useful and acceptable to those for whom it was originally intended.

BOMBAY,
1st February, 1917.

J. A. TURNER, M.D., D.P.H.

PREFACE TO THE THIRD EDITION.

THE second edition having run out of print towards the beginning of 1921, a fresh edition has become necessary to meet the demand.

In the publication of this edition, the original plan and object have been adhered to, and the book has been thoroughly revised and brought up-to-date. The sections on water, plague, tuberculosis, leprosy and influenza have been re-written and much fresh material inserted in almost every chapter. The latest available statistics have been given and the index has been made more copious.

For this I am indebted to my late colleagues Drs. Sorab C. Hormusjee, K. B. Shroff, C. Coutinho and Mr. N. S. Kowshik, to whom I again give my most grateful thanks.

My thanks are also due to Mr. De Joss, Conservancy Supervisor, who has revised and partly re-written the portion dealing with rats in relation to plague after a special study of the subject at the Government Plague Laboratory at Poona.

I regret, however, that owing to the sad death of Dr. Goldsmith in December 1919, I have been denied in the preparation of this edition the very valuable assistance which he so abundantly gave in the preparation of the first two.

BOMBAY,
February, 1922.

J. A. TURNER, M.D., D.P.H.

PREFACE TO THE FOURTH EDITION.

THE Third Edition published in 1922 having been exhausted, the Publishers have called for a revised edition. The opportunity of revision thus afforded is both an honour and a privilege. In the words of the late Sir Pherozeshah M. Mehta, Dr. Turner was a missionary of Sanitation in India. Dr. Turner conceived the idea of presenting the fruit of his knowledge and experience in the form of this " handy and practical guide " for the benefit of " Municipalities and others interested in questions of Public Health and Hygiene." His death in August 1922 created a void difficult to fill. His work is, however, writ large on the face of Bombay. The several Institutions which he brought into being with the support of Government and private and public philanthropy and made over, on his retirement from India, to the Municipal Corporation, bear ample testimony to the foresight and energy with which he laboured for the improvement of the health and sanitation of the City. It is unfortunate that, unlike its predecessors, this edition should miss his guiding hand.

The work of revising the book has been a labour of love to all who have helped in it: Drs. Sorab C. Hormusjee, C. Coutinho, R. K. Mhatre, J. V. Shirgaoker, B. S. Kanga, Mr. C. De Joss, Head Conservancy Supervisor, and Dr. S. H. Kamat, all of whom, except the last, were like myself, associated with Dr. Turner for several years in the Public Health administration of this City; and to all of them, I tender my grateful thanks. Dr. K. B. Shroff had helped in the preparation of the earlier editions, but his sad death in October 1930 deprived this edition of his assistance.

No effort has been spared in making the book thoroughly up-to-date. Much new matter has been introduced in every Chapter. The Chapters on "Food" and "Malaria and Mosquitoes" have been entirely re-written; every other Chapter has been brought up-to-date with necessary alterations and additions; Chapters on "Air and Ventilation," "Soils and Building Sites" and "Village Sanitation" have been added; several new illustrations have been inserted and some old ones withdrawn. It is hoped that the usefulness of the book has thus been materially enhanced.

Warm thanks are due to Mr. V. S. Bhende, B.A., Head Clerk of the Health Department, for his assistance in the correction of proofs.

BOMBAY,
January, 1934.

J. S. NERURKER,
B.SC., L.M. & S., D.P.H.

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CHAPTER I.

ADMINISTRATION OF PUBLIC HEALTH ACTS IN INDIA.

THE Acts and Bye-laws, which regulate and control Public Health in different parts of the world, vary with the progressive tendency of the people.

In England, the Public Health Act, 1875, forms the basis of all laws regulating and dealing with the control of Public Health, and these laws are extended or curtailed to meet the requirements of any particular locality.

The English Public Health Acts apply to urban and rural districts and some are adoptive, but it is the tendency of every urban and rural district to adopt all those sections relating to Public Health.

The laws controlling Public Health in India are administered by the Municipality and comprise the Bombay Municipal Act and Bye-laws, and the District Municipal Act and Bye-laws, the Calcutta Municipal Act and Bye-laws, the Madras Municipal Act and Bye-laws. There are also the Cantonment Municipal Acts and the Municipal Act of Native States, where Municipalities exist.

These Acts are very different in many respects, especially those sections dealing with Buildings, Housing, Overcrowding, Registration of Births and Deaths, Nuisances, Disposal of the Dead and Control of Infectious Diseases.

In large cities and towns in India, the executive control is vested in the officer appointed by Government. In Bombay he is called the Municipal Commissioner; in Madras, Commissioner; and in other towns, Chief Municipal Officer; in the Districts, with a population of not less than 100,000, and also in other Districts where specially appointed, the Municipal Commissioner (Bombay Act VIII of 1914). In Calcutta, the Chief Executive Officer is appointed by the Corporation.

Certain sections of these Acts make it incumbent on the Executive Officer to obtain the sanction of the Standing Committee of the Corporation, or Commissioners, or the Council before taking action.

The Public Health Acts in British India, therefore, vary in degree according to the character of the district, urban or rural, and are amended and added to from time to time.

They are based on the English Public Health Act, 1875, and other English Acts; the Municipal Executive Officer—Commissioner, Chairman, President or Collector—taking the place of the Sanitary Authority in the English Act.

Notices are signed by the Municipal Commissioner or the Chief Officer as the case may be.

Under certain sections of the various Indian Municipal Acts, the local Authority has power to make Bye-laws.

In the larger cities in the Presidencies of Bombay, Calcutta and Madras, the Executive Health Officer and the Executive Engineer are appointed by the Municipalities subject to the approval of Government, and the subordinate staff by the Commissioner, or the Municipality. The staff varies according to the size and importance of the city.

SANITARY ADMINISTRATION.

The Public Health Administration in England is now controlled first, by the Ministry of Health, a Department of Government; secondly, by County Councils who appoint a County Medical Officer of Health; thirdly, by the Urban and Rural District Council; fourthly, by the Parish Council. In many counties of England, there is a County Medical Officer of Health, and in addition there are combined districts comprising urban and rural areas, which also appoint a whole-time Medical Officer of Health for the combined district; and there are also Medical Officers of Health of large cities, county boroughs and smaller towns and rural districts: in the case of these latter, the M. Os. may or may not be whole-time

officers. All these officers are appointed by the various local Authorities subject to the sanction of the Ministry of Health and, in the majority of cases, are whole-time men and half their salary is paid by the County Council out of the County rates.

The local Authority administers the various Acts concerned with the Public Health, *viz.*, the Public Health Act, 1875, and the Public Health Act, 1890 ; the Rivers Pollution Prevention Act, the Factory and Workshops Act, Housing of the Working Classes Acts, Infectious Diseases Prevention Act, the Sale of Foods and Drugs Act, the Margarine Act, the Dairies, Cowsheds and Milk-shops Orders, Canal Boats Act, Infant Life Protection Act, &c.

In large cities of England, the local Authority is the Corporation, which is divided up into Committees for different Departments,—Health Committee, Cleansing Committee, Lighting Committee, Streets and Buildings Committee, etc.

In London, the County Council is the local Authority with separate medical and administration staff, &c., but for Public Health Administration, London is divided into 42 Metropolitan Boroughs, and the City and Port of London each having its own Medical Officer of Health, Engineer, &c.

The Ministry of Health is the supreme Authority and can insist on the proper administration of the Acts by the local Authority.

In India the sanitary administration of many large cities is carried on by a municipality with a Chairman, Commissioner or President, appointed by Government.

In Bombay, the local Authority is the Corporation, with a Commissioner appointed by Government. The Municipality of Bombay is the controlling body, and is comprised of a Corporation partly nominated by Government, partly elected by rent payers, the Chamber of Commerce, the

University, the Indian Merchants' Chamber and Bureau, the Bombay Millowners' Association and delegates of the registered Trades Union.

In Calcutta, this Authority is called Corporation, with a Chief Executive Officer appointed by the Corporation subject to the sanction of Government, and the Councillors are elected as in Bombay, by rent payers and nominated by Government, and elected by the Chamber of Commerce, &c.

The local Government is the supreme Authority and can insist on the proper administration of the Acts.

The Executive in Bombay consists of the Municipal Commissioner appointed by Government.

The Executive Health Officer, the City Engineer and the Hydraulic Engineer are appointed by the Corporation, subject to the approval of Government.

In Madras, the local Authority is the Corporation with a Commissioner appointed by Government, and the Health Officer now appointed by the Corporation.

In the other towns, Cawnpore, Ahmedabad, Poona, Surat, Delhi, Lahore, Lucknow, Agra, Nagpur, &c., the local Authority is the Municipality.

The Government Sanitary Service in India consists of a Public Health Commissioner to the Government of India and a Director of Public Health to each local Government, and in addition Assistant Directors of Health.

The Government of India have within recent years decided to improve and strengthen the Sanitary Service, and the following is the Resolution dealing with Sanitation in India :—

No. 921.—36, dated Simla, the 23rd May 1912.

RESOLUTION.—By the Government of India, Department of Education (Sanitary).

" The Government of India have had for some time under their consideration the question of the improvement and strengthening of the sanitary services in India. The Plague Commission in 1901 strongly urged the necessity for the improvement in certain directions of the organization of

the Sanitary Department in India, with the object of dealing more effectively with outbreaks of plague and other epidemics and with the general sanitation of India. In 1905 a scheme was formulated by the Royal College of Physicians for the creation of a medical and sanitary organisation in India, and the inadequacy of the sanitary services, as then constituted, was again emphasised.

In 1907 the Government of India addressed all local Governments inviting them to consider certain proposals for reform. The views of local Governments have been considered in detail, and a scheme has now been formulated which has received the sanction of the Secretary of State. The object of this Resolution is to indicate for general information the lines on which it is proposed that reorganization should proceed.

2. The administrative machinery of the Sanitary Department is already in most respects fairly complete and efficient. The improvements that the Government of India desire to effect are in the direction of further decentralisation of control; of widening the field of recruitment by throwing open the higher posts to fully qualified Indians of proved aptitude; of strengthening the staff in some provinces in which at present it is admittedly inadequate.

3. Hitherto the appointment of Sanitary Commissioner in all provinces with the exception of Madras and Bombay, has rested with the Imperial Government. The Government of India have now authorized all local Governments to select their Sanitary Commissioners from officers serving in the Provincial Sanitary Department, provided that no officer of less than fifteen years' service be appointed without their previous sanction. They will also retain the selection in their own hands when no suitable officer is available in the province, or when the local Government desires to appoint an officer serving in another province. The Government of India further do not consider it desirable that there should be any limitation to the tenure of the Office of Provincial Sanitary Commissioners and the existing orders on the subject contained in the Home Department Resolution No. 4340-51, dated the 7th June 1888, are cancelled.

4. It has become evident that the existing number of Deputy Sanitary Commissioners in more than one province is inadequate in view of the exacting nature of the duties which they have to perform, and the unwieldy size of their charges. The area served by these officers ranges from 129,241 square miles in Madras to 24,597 square miles in Bombay and the population from 36½ millions in Madras to 3½ millions in Bombay. The Government of India have now decided to create eight additional appointments of this class, two each in the three provinces of Madras, Bengal and the United Provinces and two which were originally proposed for Eastern Bengal and Assam. The allotment of these posts, with those sanctioned for Bengal, will require re-adjustment in view of the recent administrative changes.

The appointments of Deputy Sanitary Commissioners will no longer be reserved for officers of the Indian Medical Service, and Indians possessing the necessary qualifications will be eligible for these posts. The selection of

candidates for Deputy Sanitary Commissionerships, whether officers of the Indian Medical Service or not, will remain with local Governments subject to the following conditions :—

(1) that the candidate holds a British diploma in public health and a registrable medical qualification ;

(2) that no officer is appointed who is not an accepted candidate for the Sanitary Department ; and

(3) that the Government of India is asked for an officer when the local Government has no candidate available who is qualified and on its accepted list of candidates.

5. The Government of India consider that the terms to be offered to Deputy Sanitary Commissioners, not belonging to the Indian Medical Service, should be non-pensionable, but that the scale of pay should consequently be fixed at rather more than two-thirds of the pay of Indian Medical Service officers in the department. The scale which they have determined is as follows :—

Years of Service.	Rs.
1–2 (probationary)	500
3–5	600
6–10	700
11–15	800
16 and over	900

For approved service of over 20 years, pay of Rs. 1,000 will be given up to 25 years which will ordinarily be the limit of service. Officers appointed on this scale will be eligible for leave under the Indian Service Leave Rules. First appointments will be made on probation for a period of not less than two years, and no officer will receive any increment of pay during the probationary period of his service ; but in the case of men who have rendered approved service as municipal officers of health, the period of probation may be dispensed with at the discretion of local Governments and the full rate of pay (*viz.*, Rs. 600) allowed. All Deputy Sanitary Commissioners will be debarred from private practice.

6. Another part of the administrative machinery which has attained a position of varying usefulness in different provinces is the Sanitary Board. These Boards are beneficial in emphasising the importance of the subject of sanitation, in correlating sanitary schemes with administrative exigencies and in securing direct discussion between sanitary experts and those who can appreciate and represent the attitude of the general population. The constitution of these Boards should, the Government of India consider, be determined by the local Government with reference to the functions with which they are to be entrusted. If the Board is purely an advisory body, it should contain the smallest number of persons sufficient to ensure that projects submitted to it will be examined adequately from the points of view of public health, of engineering and of finance and general administration. If the Board has specific powers of sanction, and is, within certain limits, practically to represent the local Government in matters of

sanitation, it will appropriately be larger; but it cannot, in the Government of India's opinion, be desirable that a large body of officials without power to sanction schemes should be interposed between the local authorities and the provincial Government.

7. The weakness of the executive establishment of the service, and the inadequacy of the staff of trained officers of health, is a defect which has been prominently brought to the notice of the Government of India, the remedy for which is a necessary preliminary to any substantial improvement of sanitation. The Presidency towns and a few of the larger cities have such officers; but as a rule the Civil Surgeon is the only health officer of the towns in a district. It is difficult for him to give sufficient attention to the sanitary requirements of the head-quarters town; it is impossible for him to make more than an occasional inspection of other towns. The scheme now sanctioned provides for the appointment of health officers of the first class for larger municipalities and of the second class for the smaller towns, in accordance with detailed proposals received from the local Governments. A health officer of the first class will be required to have a registrable medical qualification and a British diploma in public health. The necessity for a British diploma will however be only temporary, as the Government of India trust that it may be possible to remove the second restriction so soon as arrangements can be made in India which will enable Indians trained in this country to become health officers of the first class. For health officers of the second class the main qualifications will be a good general education, supplemented by a course of training in public health approved by the local Government. A salary of Rs. 300-20-500 is considered suitable for officers of the first class (with higher pay in exceptional cases) and of Rs. 150-10-300 for officers of the second class. The Government of India leave it to local Governments to determine in the case of both classes, whether provincial service should be constituted or whether the appointments should be local; but they consider that grants-in-aid by local Governments should be made only on conditions which will ensure that qualified men are appointed, and that they will have reasonable security of tenure. They also consider that the necessary power should be vested in local Governments to require a municipality to appoint a health officer and to veto the appointment of an unfit person.

In order to assist local Governments to establish this trained service, the Government of India have offered to grant an annual subsidy to those Governments which cannot find the money from provincial funds, to the extent of the entire cost of the additional Deputy Sanitary Commissioners (calculated at the rates proposed for men not belonging to the Indian Medical Service) *plus* half the cost of the municipal health officers in the towns in which local Governments consider they should be appointed. It is hoped that the balance can then be found by the municipalities and local Governments concerned.

8. The subordinate supervising staff of the conservancy establishment also calls for improvement. In most towns there is an official whose functions resemble those performed by an inspector of nuisances in England.

It is however exceptional to find in this position a man who has any technical knowledge of his work. The Government of India think it desirable that a service of trained sanitary inspectors should be organized in municipalities, based on such standard of population, income or area as commends itself to the local Governments. They have recommended to the notice of the other provinces the system in force in Madras, whereby every municipality is required to employ at least one trained inspector, a second inspector if the population exceeds 30,000 and three inspectors if the population exceeds 50,000; but they leave it to local Governments to determine the preliminary qualifications to be required from candidates, the course of training they must undergo and the rates of pay to be given. They trust that local Governments will be able to give assistance to such municipal bodies as require it in the organization of this subordinate staff.

9. The Government of India are confident that the schemes now sanctioned will mark a substantial advance towards the organization of a trained sanitary staff capable of further expansion in the future, and that it will prove an efficient agency for extending a knowledge of elementary hygiene among the people."

This G. R. is further modified by—

G. R. No. 2815 of 14th February 1923 (General Department) which lays down (*i*) that Medical Officers of Health of Municipalities of the first class shall be required to possess—

(*a*) a Medical qualification registrable by the General Council of Medical Education and Registration in the United Kingdom and

(*b*) a British Diploma in Public Health or the degree of Bachelor of Hygiene of the Bombay University or the Diploma in Public Health of the Calcutta University or such other equivalent Indian Diploma as may be hereafter approved by Government.

(*ii*) that the rates of pay for Medical officers of Health of 1st grade towns shall be as follows :—

(*a*) for Health Officers possessing British qualifications Rs.400-25-750;

(*b*) for Health Officers possessing Indian qualifications approved by Government Rs. 300-25-600.

SANITARY ADMINISTRATION OF TOWNS IN INDIA.

Towns in India, in which any attempt at sanitary administration is made, vary in population from 30,000 to 1,000,000. In the majority of the smaller towns, the duties of the Health Department, if one exists, are very ill-defined and perfunctorily carried out. No actual hard and fast rules can be laid down—much depending on the rateable value, the commercial enterprise and importance as a residential centre, the class

of inhabitants, the climatic conditions and facilities for communication.

In view of the desire of the Government of India to improve the sanitary administration of the Empire, certain principles may be laid down with regard to the following :—

1. Water-supply.
2. Drainage and Sewage disposal.
3. Refuse collection and disposal.
4. Registration of Births and Deaths.
5. Control of Infectious Diseases.
6. Supervision and Control of Trades and Factories.
7. Condition of Houses, their improvement.
8. Re-arrangement of crowded areas and Town-planning.
9. Medical Relief, Malaria, Tuberculosis.
10. Disposal of the Dead.
11. Pollution of Rivers and Wells.
12. School Medical Inspection.

A Health Officer should be appointed either in a town or combined district with 30,000 persons or more. He should be a qualified medical man with experience in public health work.

He should have a staff of Conservancy and Sanitary Inspectors—one to each 20,000 population.

For the registration of births and deaths, there should be a Registration Office, with Branch Offices if the district has a population of over 50,000—or is a combined one.

The Registrars should be qualified medical men, or Sub-Assistant Surgeons, with training in sanitation.

On taking over charge of a town or district, the Health Officer should first obtain an accurate map giving the area, number of inhabited houses, streets, lanes and oarts and the

population of each section. He should divide the district into sections and put each section under a Sanitary Inspector, who should be an educated and trained man.

The extent of labour staff required will depend largely on the particular industry or occupation of the people concerned.

Details of every street and house should be available and a house to house inspection made by the Sanitary Inspectors and the method of drainage, night-soil disposal, and refuse collection and disposal laid down.

In every town or district of any size, a large number of huts or small houses exist occupied by the poorest classes.

It is not to be expected that modern sanitary methods which are adopted in large cities can be applied here, but some attempt can be made to improve their surroundings.

In the majority of these districts it will be many years before the inhabitants can be taught the value of cleanliness in and around the dwellings: nor will it be possible to remove *all* sullage water and night-soil or adopt other than existing methods, but there are many ways of improving the sanitation of a district besides expensive drainage schemes.

Land is plentiful and labour is cheap and the climate is favourable for disinfection by the sun and wind.

These conditions should be taken advantage of, for even the poorest class of huts can be improved by regulating their position and putting a mukadam in charge who can supervise the cleaning of the surroundings, disposal of night-soil, filling in of damp places and keeping of a register of births, deaths and sickness.

BOMBAY.

Bombay may be taken as an example of a large city in India where modern sanitary methods are applied.

The population of Bombay is about 1,200,000 and in point of numbers it is the third city in the Empire.

	Name of City.	Population according to the Census of 1931.	Area in 1931.
(1)	Bombay	11,61,383	15,480 acres.
(2)	Calcutta & Suburbs	14,19,321	19,520 ,,
(3)	Madras	6,47,533	18,560 ,,

	Name of City.	Rateable value in Rs.	Annual expenditure. Cleansing Department. Rs.
(1)	Bombay	13,50,26,397	29,81,147
(2)	Calcutta & Suburbs	9,84,14,683	23,87,000
(3)	Madras	2,16,18,915	9,46,744

For administrative purposes the city has been divided into seven wards. The head of the Health Department is the Executive Health Officer who has the following officers immediately under him :—

(1) 5 Assistant Health Officers.

(2) 1 Head Supervisor.

(3) 1 Superintendent of Vaccination.

(4) 1 Medical Superintendent in charge of Isolation Hospitals.

(5) 1 Municipal Analyst.

(6) 2 Medical Officers in charge of Tuberculosis Institutions.

(7) 1 Medical Officer in charge of Venereal Diseases Dispensary.

(8) 5 Lady Doctors in charge of Maternity Homes.

The Executive Health Officer is under the Municipal Commissioner, the Chief Supervising Officer.

DUTIES OF THE STAFF.

The duties of the staff are on the same lines as those in English cities, but are of a more multifarious and exacting character. The habits of the people, their caste prejudices and religious susceptibilities and the difficulties of enforcing

the Acts and Bye-laws and the control of a large staff of labourers render the work of the Health Officer much more arduous; and he must be as much a teacher as an Executive Officer and while exercising tact and discretion, must possess a firm guiding hand both with regard to the people and the authorities under whom he serves.

SANITARY BRANCH.

For sanitary purposes the seven wards have been grouped into four divisions, each of which has been given under the charge of an Assistant Health Officer who is the Health Officer of the division with a population of 175,000 to 350,000. The Assistant Health Officer is responsible for the sanitary work of the ward or wards under his control. The other staff of the Sanitary Branch exclusive of the clerical and labour staff consists of :—

- 10 Senior Medical Inspectors, who are also District Registrars in charge of the ten Registration Districts of the City.
- 7 Junior Medical Inspectors.
- 39 Medical Assistants in charge of Sections.
- 6 Milk Sub-Inspectors.
- 10 Food Jamadars.
- 11 Disinfecting Sub-Inspectors.

DUTIES OF THE ASSISTANT HEALTH OFFICERS.

General Duties.

The first duty of the Assistant Health Officer is to make himself thoroughly acquainted with the boundaries and character of his ward sections and sub-sections, the number and members of the supervising staff of these areas, and the number and description of the labour staff working under him.

The Assistant Health Officer will exercise full administrative control of his ward under the supervision of the Executive Health Officer and be held responsible for the carrying out of the sanitary provisions of the Municipal Act, subject to

such orders as may from time to time be issued by the Municipal Commissioner or the Executive Health Officer.

Certain powers under the Municipal Act are delegated to the Assistant Health Officers and they must study the sections of the Act generally so as to be conversant with the legal powers and duties and the various functions conferred upon the Municipal Corporation and its Officers.

These powers must be carefully and judicially exercised; firmly but not oppressively, it being always borne in mind that a perfunctory or illegal use of authority might lead to serious consequences, for which the officer concerned would be held responsible.

The Assistant Health Officers will report to, and correspond direct with, the Municipal Commissioner on matters of special importance, or such as may be referred to them from time to time, and with the Executive Health Officer, and all other Municipal executive and departmental officers or persons, public or private, regarding all matters of routine, sanitary control and divisional work.

The Executive Health Officer is, under the Municipal Commissioner, the chief supervising officer and Assistant Health Officers shall obey and carry out such orders or requests as he may from time to time issue; and they shall furnish him with reports and returns and all information which he may deem necessary.

In matters of general policy and the working of the Department, no change, alteration, or interference must be attempted without reference to the Executive Health Officer, whose approval and consent should in all cases be first obtained. Subject to the foregoing and any orders which may be hereafter issued from time to time by the Municipal Commissioner and the Executive Health Officer, the Assistant Health Officers will be in independent charge of their wards and held responsible for the proper and efficient working of the same.

An Assistant Health Officer will ordinarily visit and inspect a certain portion of his ward daily, morning or evening, and at least once during the month on a Sunday, the inspections being arranged so that every portion of the ward may be regularly and frequently visited. A diary should be kept as a record of these visits, which may be called for at any time by the Municipal Commissioner, or the Executive Health Officer.

It shall be a part of the Assistant Health Officer's duty to cause a careful enquiry to be made into all cases of death ascertaining, if possible, the cause, and when an unusually large number of deaths occur in any house or street or section to bring the same promptly to the notice of the Municipal Commissioner and the Executive Health Officer.

Specific Duties.

The following are the specific duties of the Assistant Health Officers :—

To inform himself as far as practicable respecting all influences affecting or threatening to affect injuriously the public health in his ward.

To enquire into and ascertain the causes, origin or distribution of diseases within his ward, and to ascertain to what extent the same has depended on conditions capable of removal or mitigation.

By systematic and daily inspection in his ward to keep himself informed of the conditions injurious to health existing therein.

To exercise full administrative control over his ward and to carry out the sanitary provisions of the Municipal Act.

To supervise the work of the senior and junior medical inspectors and medical assistants in charge of sections.

To supervise the work of district registrars, and medical assistants in charge of dispensaries and offices, to enquire into any outbreak of infectious disease reported by the district registrar, to arrange and supervise removal to hospital, disinfection and other measures necessary for dealing with such cases of infectious diseases.

To supervise the carrying out of all special Plague measures such as disinfection, evacuation of infected houses, removal of cases to hospital and contacts to health camps, and supervision of health camps in his ward.

To enquire into complaints made by the public, and to make reports thereon when required to the Executive Health Officer and the Municipal Commissioner.

To serve notices on owners of premises in which there are sanitary defects and to conduct prosecutions in the Police Court of offenders against the sanitary provisions of the Municipal Act.

To carry out all orders and instructions of the Municipal Commissioner and the Executive Health Officer.

Routine Duties.

The daily routine work of an Assistant Health Officer consists of a visit to his ward and dispensary and inspection of some part or parts of his ward in the early mornings between 7 and 9 A.M.; and office work and outdoor supervision if necessary, from 11 to 5 P.M. or later.

Places or premises are visited for enquiry into complaints made by the public, which cannot be dealt with by the medical assistants in charge of sections, or for reports to be made to the Municipal Commissioner or Executive Health Officer.

Inspection of premises in which the privy accommodation is insufficient or for sanitary reasons objectionable, for action to be taken under Sections 248 and 249.

Inspection of premises for which notices for limewashing and sanitary improvements under Sections 257, 375 and 377 have been served, to see if the work has been satisfactorily carried out.

Inspection of licensed stables with special reference to the carrying out of the requirements of the bye-laws, prevention of overcrowding, daily removal of dung and litter. And in cases of milch cattle stables for prosecutions for feeding the cows and buffaloes, etc., on stable litter under Section 384, Clause (*c*).

Inspection of houses where cases of plague or other infectious disease have occurred or which are insanitary, for reports to be made to the Executive Engineer for action to be taken for their improvement.

Inspection of hotels, restaurants, eating houses, tea shops, dairies and bakeries, hair dressing saloons, bidi manufactories, and stables.

Inspection of places where refuse is thrown into the gullies and streets for prosecutions under Section 372 clauses *a*, *e*, and *f* and Section 373.

Inspection of food exposed for sale and seizing of the same if necessary under Sections 413 to 417.

Collecting samples of milk, ghee, butter, foods and drinks and forwarding them to the Municipal Analyst (now Public Analyst) for analysis.

Inspection of factories, &c., for smoke nuisance and actions under Section 391.

Inspection of District Offices, Municipal Dispensaries and Maternity Homes, visiting houses where cases of infectious diseases have occurred making enquiries in the origin of infection, supervising disinfection, persuading relatives to remove cases to the hospitals for infectious diseases, supervision of plague measures and supervision of health camps.

Supervision of the work of the nurses, birth karkoons, and death registration ramoshis.

Inspection of special premises about which action is being taken in the Police Courts.

Visiting premises for reporting to the Municipal Commissioner if licenses for stables or firewood depots should be granted or for permits for premises at which mechanical power is proposed to be employed.

Inspections on above lines are made in the early mornings and afternoons.

The office work of each Assistant Health Officer includes the writing of reports to the Municipal Commissioner and the Executive Health Officer, reporting to the Executive Engineer, Drainage Engineer, and Hydraulic Engineer for action required to be taken by their Departments; reporting to the Superintendent of Licenses the infringement of the terms of their licenses by licensees of stables and other licensed premises.

Drafting and signing letters in reply to complaints or requiring house-owners to carry out certain works.

The preparation of the paysheets of all the supervising and labour staff.

Disposal of defaulter sheets and reports by District Registrars and Junior Medical Inspectors and Medical Assistants of offences committed daily and infliction of fines or other punishments.

Attending the Police Court to conduct cases.

Every day the Medical Assistants in charge of sections of the different Wards attend at the office of the Assistant Health Officer to report to the latter and, if necessary, he goes out with them to inspect or deal with any urgent nuisances.

The other staff of the division in charge of an Assistant Health Officer consists of his office staff and outdoor staff of

Medical Inspectors, Medical Assistants, Visiting Nurses, Birth and Death registration Karkoons, Milk and Disinfecting Sub-Inspectors, Cemetery clerks who are in charge of cemeteries and burning ghats and the menial staff.

MALARIA BRANCH.

This branch is now in charge of an Assistant Health Officer who, like the Assistant Health Officers on the sanitary side, is directly responsible to the Executive Health Officer. The Assistant Health Officer (Malaria) has under him his office staff, 8 Junior Medical Inspectors, 80 Junior Overseers and the menial staff and has to carry out the work of examination of wells, tanks, fountains, basins and other collections of water for the presence of larvæ of mosquitoes or for cleaning, covering, filling in, &c., under Section 381. He is responsible for the initiation and effective execution of anti-mosquito and anti-malarial measures.

CONSERVANCY BRANCH.

Duties of the Head Supervisor.

The Head Supervisor is the head of this Branch, which includes the Halalkhore service. He is directly subordinate to the Executive Health Officer. His relation with the staff of the Sanitary branch is not that of subordination, but that of co-operation. He is responsible for the supervision and control of the whole of the conservancy of the City including town cleansing, street sweeping, refuse collections, supervision and control of halalkhore work, the control of bullock transport and subject to certain powers reserved to the Deputy Executive Engineer, Mechanical Branch, of the motor wagons allotted to the Health Department. He shall make special inspections in afternoons or evenings. He shall attend at muster early in the morning and during the day at each ward stable at least once a week. Surprise visits should be paid to the stables at least twice a week to inspect the feeding of bullocks.

His morning inspections shall include supervision of the work of labour staff, *i.e.*, removal of road scrapings, cleansing of gullies, gully traps, house drains, waste water pipes, privies, flushing of gullies with gully flushing engines and reels of hose attached to stand pipes, condition of public latrines and urinals, dustbins, and removal of refuse and all the conservancy work of the City including surface cleaning.

He shall report to the Executive Engineer, Drainage Engineer and Hydraulic Engineer, defects in public latrines, stables, chawls and other buildings belonging to the Municipality which are in charge of the Health Department and shall certify the bills for the necessary works carried out.

He shall send in indents for the feed of the bullocks, for brooms, baskets, lime and other articles required by the Health Department.

He shall arrange for the removal of refuse and night-soil from military camps, circuses, private camps, &c.

He shall pay surprise visits to the various night-soil depots in his charge and inspect the register kept by the Depot Attendant.

He shall submit reports to the Executive Health Officer on outbreaks of infectious diseases or special mortality occurring in any house or section.

He shall report to the Executive Health Officer on any matters likely to affect the health of the City generally, and on any matters which should be brought to his notice.

He shall make routine inspections of the Ward stables, which are under qualified veterinary graduates. Three Veterinary Inspectors have been appointed to assist the Head Supervisor in stable inspections and cases of infectious diseases among cattle.

Adverse reports by Veterinary Inspectors on Health Department stables will, in every case, be forwarded by the Head Supervisor to the Executive Health Officer.

The other staff of the Conservancy Branch exclusive of the clerical and labour staff consists of :—

(1) 3 Supervisors.

(2) 10 Assistant Supervisors.

(3) 7 Senior Overseers.

(4) 47 Junior Overseers.

(5) 12 Depot Attendents.

(6) 10 Caretakers.

(7) 20 Nuisance Jamadars.

(8) 1 Senior Veterinary Inspector.

(9) 1 Assistant to Senior Veterinary Inspector.

(10) 3 Veterinary Inspectors.

(11) 10 Veterinary Overseers.

House drain cleaning work :—This work is done under the Assistant Supervisors, by masons and the staff of drain-cleaning bigaries of each section. In each Ward there is a gully-flushing gang in charge of an Overseer.

The labour staff is directly controlled by Mukadams.

It consists of bigaries to sweep the roads and footpaths and house-gullies ;

Cart fillers to fill the cutchra carts and cart-drivers for the carts ; motor fillers and motor drivers.

Gully plungermen to clean gully traps ;

Halalkhores to clean privies and remove night-soil to depots.

Vacant ground cleaners to remove night-soil from vacant ground, street corners, &c. ;

Public latrine and urinal cleaners ;

A staff to clean house-drains, repair broken house-drains and gully traps, sending in bills to the house-owners concerned. They also clean waste-water pipes and all connections to house-drains.

VACCINATION BRANCH.

The Head of the Branch is the Superintendent of Vaccination who under the control of the Executive Health Officer is responsible for the vaccination work in the City. The Superintendent has under him one Head Vaccinator and 9 Vaccinators besides the clerical and menial staff.

Besides there is a Medical Superintendent for the Arthur Road Hospital for Infectious Diseases and the Maratha Hospital for tubercular and roadside cases; a Municipal Analyst in charge of a fully equipped chemical and bacteriological laboratory for analytical and bacteriological examination; two Medical Officers for the Tuberculosis Dispensaries and the Sanatorium; a Medical Officer for the Venereal Diseases Dispensary and five Medical Officers (Lady Doctors) for five Maternity Homes.

DISTRICT STAFF.

For the purposes of medical relief, registration of births and deaths, and taking measures against infectious diseases the City of Bombay is divided into ten parts called Districts, and each District is in charge of a fully qualified Medical Officer, called the District Registrar, who has under him the following staff:—

1. Three or more Medical Assistants or Assistant Sanitary Inspectors whose duty is to check immediately all death reports received from cemeteries or death Karkoons, to make house-to-house inspection and find out sickness and births, to treat poor patients at their houses, to supervise disinfection, to report to the District Registrar sanitary defects observed in houses, to check the work of Birth Karkoons and to assist the District Registrar generally.

2. One fully qualified midwife, called the Nurse, whose duty is to make house-to-house inquiry, so as to instruct the female population as regards the feeding of infants, domestic and personal hygiene, and other sanitary matters, to conduct delivery cases in poor families and to find out births.

3. Three or more Birth Karkoons, one for each section, whose duty is to make house-to-house inspection, and collect information regarding births and sickness and to serve vaccination notices and bring children for vaccination.

4. Cemetery Karkoons in charge of each cemetery. In large cemeteries there are fully qualified Medical Assistants. Their duty is to register deaths at the cemeteries and to ascertain the cause of death from the relatives of the deceased.

5. Death registration Ramosis, six or more for each District. Their duty is to attend day and night at specified places in their section and to give a pass to the funeral party after personally ascertaining the proper address of the deceased. One of these death-passes is presented at the cemetery and the other is sent to the District Registrar of the District for immediate inquiry as to the cause of death.

6. A Disinfecting Sub-Inspector to carry out disinfecting operations.

7. Mukadams, a gang of coolies, camp master, clerks, peons, etc.

The District Registrar, who generally resides in his own District or close to it, is in charge of all sections of his District and is personally responsible for them. His duties are to attend both in the morning and in the afternoons, the Municipal Charitable Dispensary which is situated in the central part of his District, to treat, at their own residence, poor patients who are unable to move out of their houses, to check death reports, to supervise the work of Medical Assistants and birth Karkoons and the Nurse, to supervise the disinfection of infected houses, evacuate houses where necessary, to make special reports to the Health Officer on the outbreak of any special diseases, to report to the Assistant Health Officer all insanitary houses and any sanitary defects observed during his rounds, and to assist the Assistant Health Officer and the Health Officer generally. He has also to look

after the camps and take prompt measures to prevent the spread of sickness in them.

Each Dispensary is also the office of the District Registrar and is provided with a telephone connection to receive information of infectious diseases from the public. Special arrangement is made to receive messages at any time during the day and night. On the occurrence of cases of Plague, Cholera, Typhoid Fever, Relapsing Fever, Small-pox and Phthisis, disinfection of the infected clothes, etc., is carried out.

GUIDE TO PUBLIC HEALTH LAWS.

(Notes are local to Bombay.)

The City of Bombay Municipal Act of 1888 *as modified up to the* 1st *July* 1930.

(*a*) *The City.*—Means the City of Bombay.

(*b*) *The Corporation.*—Means the Municipal Corporation of the City of Bombay.

(*c*) *Councillor.*—Means a member of the Corporation.

(*d*) *The Commissioner.*—Means the Municipal Commissioner for the City of Bombay.

(*e*) *Bakehouse.*—Means any place in which are baked bread, biscuits or confectionery, from the baking or selling of which a profit is derived.

(*f*) *Owner.*—When used in reference to any premises means the person who receives the rent of the said premises, or who would be entitled to receive the rent thereof if the premises were let: and includes:—

I. An Agent or Trustee who receives such rent on account of the owner.

II. A receiver appointed by any Court.

(*g*) A person is deemed "*to reside*" in any dwelling which he sometimes uses, or some portion of which he sometimes uses, though perhaps not uninterruptedly, as a sleeping apartment.

(*h*) *Eating House.*—Means any premises to which the public are admitted and where any kind of food is prepared or supplied for consumption on the premises for the profit or gain of any person owning or having an interest in or managing such premises.

(*i*) *Building.*—Includes a house, out-house, stable, shed, hut and every other such structure whether of masonry, bricks, wood, mud, metal, or any other material whatever.

(*j*) *Premises.*—Includes messuages, buildings and lands of any tenure, whether open or enclosed, whether built on or not and whether public or private.

(*k*) *Water Work.*—Includes a lake, stream, spring, well, pump reservoir, cistern, tank, duct, whether covered or open, sluice, mainpipe, culvert, engine and any machinery, land, building or thing for supplying or used for supplying water.

(*l*) *A Sweetmeat Shop.*—Means any premises or part of any premises used for the manufacture, treatment or storing for sale, or for the sale wholesale or retail, of any ice-cream, confections or sweetmeats whatsoever, for whomsoever intended, and by whatsoever name the same be known, and whether the same be for consumption on or outside the premises.

(*m*) *Drain.*—Includes a sewer, pipe, ditch, channel or any other device for carrying off sewage, offensive matter, polluted water, sullage, waste water, rain water or subsoil water, and any ejectors, compressed air mains, sealed sewage mains and special machinery or apparatus for raising, collecting, expelling or removing sewage or offensive matter to the sewage outfall.

(*n*) *Land.*—Includes land which is being built upon or is built upon or is covered with water.

(*o*) *House-gully.*—A passage or strip of land, constructed, set apart or utilised for the purpose of serving as a drain or of affording access to a privy, urinal, cesspool or other receptacle for filthy or polluted matter, to municipal servants or to persons employed in the cleansing thereof or in the removal of such matter therefrom.

(*p*) *Street.*—Includes any highway and any causeway, bridge, viaduct, arch, road, lane, footway, square, court, alley or passage, whether a thoroughfare or not, over which the public have a right of passage or access, or have passed and had access uninterruptedly for a period of 20 years.

(*q*) *Public Street.*—Means any street heretofore levelled, paved, metalled, channelled, sewered or repaired by the Corporation, and any street which becomes a public street under any of the provisions of the Act.

(*r*) *Private Street.*—Means a street which is not a public street.

(*s*) *Nuisance.*—Includes any act, omission, place or thing which causes or is likely to cause injury, danger, annoyance or offence to the sense of sight, smelling or hearing or which is, or may be, dangerous to life or injurious to health or property.

(*t*) *Dangerous Disease.*—Means Cholera, Plague, Small-pox, Leprosy, Enteric or Typhoid, Relapsing Fever, Malaria, Tuberculosis, Measles, Whooping Cough, Erysipelas, Scarlet Fever, Diphtheria, Sleeping Sickness, Yellow Fever, Kala-Azar, Influenzal Pneumonia and any endemic, epidemic, or infectious disease by which the life of man is endangered.

Obligatory Duties of the Corporation—Section 61—

(*a*) Construction, etc., of drains and drainage works, and of public latrines, urinals and public conveniences.

(*b*) Supplying water.

(*c*) Scavenging, etc,

(*d*) Abatement of all nuisances.

(*e*) Regulation of places for the disposal of the dead.

(*f*) Registration of births and deaths.
(*ff*) Public vaccination.
(*g*) Prevention of the spread of dangerous diseases.
(*gg*) Public medical relief.
(*h*) Provision of markets and slaughter houses.
(*i*) Regulation of offensive and dangerous trades.
&c. &c. &c. &c.

Section

68 (1) The Municipal Commissioner may empower in writing any Municipal Officer to perform, under the Municipal Commissioner's control and subject to his revision, any of the powers, duties or functions described in sub-section (2) and the word "Commissioner" includes such officer so empowered.

(2) The sections, sub-sections and clauses of this Act referred to in sub-section (1) (*pertaining to the Health Department*) are the following :—

84–92–112–228–234–240–243 (2)–246A – 248–249–249 A 250 (2)–251–251B–253–257–258 (*a*), (*b*), (*c*)–368–374–375 375A–377 – 379–379A– 380–381–381A–383–384–384A–394–396 (1)–410 (1)–412 (1), (2)–412A–413 (1)–415–416–422–424 (1)–425 (1)–427 (3)–479 (5)–488 and 517 (*a*).

LEAVE OF ABSENCE, ACTING APPOINTMENTS, &C.

81 Standing Committee to frame regulations for grant of leave, etc.

83 Power of suspending, punishing and dismissing vests in the authority by whom such officer or servant is appointed.

84 Leave of absence may be granted by the Municipal Commissioner.

86 Municipal Officer or servant not to be intérested in any contract, etc., with the Corporation.

141 Water tax on what premises to be levied.

142 Halalkhore tax on what premises to be levied.

181 Exemptions from the tax on vehicles and animals kept for Municipal purposes.

220 *Municipal Drains.*—Municipal drains to be under the control of the Municipal Commissioner.

220A Vesting of water courses.

221 Drains to be constructed and kept in repair by the Municipal Commissioner.

222 Power of making drains.

223 Buildings should not be erected without permission over any Municipal drain.

224 Alteration and discontinuance of drains.

225 Cleansing of drains.

Section

227 *Drains of Private Streets and Drainage of Premises.*—Power to connect drains of private streets with Municipal drain.

228 Power of owners and occupiers of premises to drain into Municipal drains.

229 Connections with Municipal drains not to be made except in conformity with section 227 or 228.

230 Rights of owners and occupiers of premises to carry drains through land belonging to other persons.

231 Municipal Commissioner may enforce drainage of undrained premises situated within a hundred feet of a Municipal drain.

232 Municipal Commissioner may enforce drainage of undrained premises, not situated within 100 feet of a Municipal drain.

232A Municipal Commissioner may enforce drainage of premises in combination.

233 Municipal Commissioner may close or limit the use of existing private drains.

233A Vesting and maintenance of drains for sole use of properties.

234 New buildings should not be erected without drains.

235 Excrementitious matter not to be passed into cesspool, except with permission of the Municipal Commissioner.

236 Obligation of owners of drains to allow use thereof or joint ownership therein to others.

237 How right of use or joint ownership of a drain may be obtained by a person other than the owner.

238 Municipal Commissioner may authorize person other than the owner of a drain to use the same or declare him to be a joint owner thereof.

239 Sewage and rain water drains to be distinct.

240 Drains should not pass beneath buildings.

241 Cesspools not to be constructed beneath buildings nor within 20 feet of any well, etc.

242 Right of Corporation to drains, etc., constructed, etc., at charge of Municipal Fund on premises not belonging to the Corporation.

243 All drains and cesspools to be properly covered and ventilated.

244 Municipal Commissioner may affix pipes to any building, etc., for ventilation of drains, etc.

DISPOSAL OF SEWAGE.

245 Municipal Commissioner may appoint places for emptying of drains and disposal of sewage.

246 Provision of means for disposal of sewage.

WATER-CLOSETS, PRIVIES, URINALS, &c.

Section

246A (1) No water-closet or privy for any premises should be constructed except with the written permission of the Municipal Commissioner who may determine—

(2) (a) Whether the premises shall be served by a water-closet or by a privy, and

(b) the site or position of each water-closet or privy.

(3) If any water-closet or privy is constructed in contravention of sub-section (1), the Municipal Commissioner, with the approval of the Standing Committee, can demolish the same.

247 (1) Water-closet and other accommodation, including washing and bathing places, should be provided in buildings newly erected or re-erected, and

(2) In prescribing such accommodation the Municipal Commissioner may determine in each case—

(a) whether water-closet or privy should be erected, and

(b) prescribe the site or position of each water-closet, privy, urinal, or bathing or washing place, and their number.

248 When any premises are without a water-closet or privy or urinal, or bathing or washing place, or such existing accommodation is insufficient, inefficient, or on any sanitary grounds objectionable, the Municipal Commissioner, with the approval of the Standing Committee, may take action for such requirements.

N.B.—The usual rule of the Health Department is to demand one privy seat for every 5 rooms, each occupied as a separate tenement.

[The standard under the Indian Factories Act (XII of 1911)—

Chapter III (13): Every factory shall be provided with sufficient and suitable latrine accommodation, and if the Local Government so requires, with separate urinal accommodation for the persons employed in the factory. Provided that the Inspector may, subject to such conditions as the local Government may lay down in this behalf, by an order in writing exempt any factory from the provisions of this section.

SECTION 37 (2) (*h*):—STANDARD OF LATRINE AND URINAL ACCOMMODATION.

22 (1) Every factory which has not been exempted under the proviso to Section 13 of the Act, shall be provided with latrine accommodation, which shall be in a place detached from the other factory buildings and on the following scale:—

	Seats.
Where the number of operatives does not exceed 20 ..	1
Where the number exceeds 20 but does not exceed 35..	2
Where the number of operatives exceeds 35 but does not exceed 50	3

	Seats.
Where the number of operatives exceeds 50 but does not exceed 150	4
Where the number of operatives exceeds 150 but does not exceed 200	5
Where the number of operatives exceeds 200 ..	1 seat for every 50 or fraction of 50.

(2) If females are employed, separate latrines screened from those for males and marked in the Vernacular in conspicuous letters "for females only" shall be provided. Those for males shall be similarly marked "for men only".

(3) In factories which employ more than 100 hands and which do not provide flushing arrangements in the latrines one urinal shall be provided for every 100 operatives or fraction of 100.

The standard under the English Factory Act is as follows :—

The accommodation in the way of sanitary conveniences provided in a factory or workshop shall be deemed to be sufficient and suitable within the meaning of this section if the following conditions are complied with and not otherwise :—

1. In factories or workshops where females are employed or in attendance there shall be one sanitary convenience for every twenty-five females.

In factories or workshops where males are employed or in attendance there shall be one sanitary convenience for every twenty-five males : provided that—

(*a*) in factories or workshops where the number of males employed or in attendance exceeds one hundred, and sufficient urinal accommodation is also provided, it shall be sufficient if there is one sanitary convenience for every twenty-five males up to the first hundred, and one for every forty after;

(*b*) in factories or workshops where the number of males employed or in attendance exceeds five hundred, and the district inspector of factories certifies in writing that by means of a check system or otherwise, proper supervision and control in regard to the use of the conveniences are exercised by Officers specially appointed for that purpose, it shall be sufficient if one sanitary convenience is provided for every sixty males, in addition to sufficient urinal accommodation. Any certificate given by an Inspector shall be kept attached to the general register, and shall be liable at any time to be revoked by notice in writing from the Inspector. —

In calculating the number of conveniences required by this Order, any odd number of persons less than twenty-five, forty, or sixty, as the case may be, shall be reckoned as twenty-five, forty or sixty.

2. Every sanitary convenience shall be kept in cleanly state, shall be sufficiently ventilated and lighted, and shall not communicate with any work-room except through the open air or through an intervening ventilated space: provided that in work-rooms in use prior to 1st January 1903, and mechanically ventilated in such manner that air cannot be drawn into the work-room through the sanitary convenience, an intervening ventilated space shall not be required.

3. Where persons of both sexes are employed, the conveniences for each sex shall be so placed or screened that the interior shall not be visible even when the door of any convenience is open, from any place where persons of the other sex have to work or pass; and, if the conveniences for one sex adjoin those for the other sex, the approaches shall be separate.

Section

255 When the expenses of inspection and examination are to be paid by the Municipal Commissioner.

256 When the expenses of inspection and examination are to be paid by the owner.

257 Municipal Commissioner may require repairs, &c., to drains, ventilation shaft, or pipe, cesspool, house-gully, water-closet, privy, latrine, urinal, bathing or washing place to be made.

257A Cost of inspection and execution of works in certain cases.

258 No person shall—

(*d*) Drop, pass, or place, or cause or permit to be passed, dropped or placed into or in any drain, any brick, stone, earth, ashes or any substance or matter by which such drain is likely to be obstructed;

(*e*) Pass, or permit or cause to be passed into any drains provided for a particular purpose, any matter or liquid for the conveyance of which such drain has not been provided;

(*N.B.*—Action for passing dung into drains in milch-cattle stables is taken under these sub-sections).

(*f*) Discharge into any drain any hot water, steam, fumes or any liquid which would prejudicially affect the drain.

260 Municipal Commissioner may execute certain works, under this chapter of the Act, without allowing option to persons concerned of executing the same.

265 Power of carrying water mains, etc.

267 Prohibition of building and other acts which would injure sources of water-supply.

268 Buildings, &c., not be erected over Municipal water main without permission.

274 Provision as to storage cisterns and other fittings, &c., to be used for connections with water-works.

275 Water pipes, &c., to be kept in efficient repair by owner or occupier of premises.

278 Municipal Commissioner may inspect premises in order to examine taps, water fittings, &c.

279 Power to cut off private water-supply or to turn off water.

281 Water pipes not to be placed where water will be polluted.

294 Minimum width of new public streets—40 feet if made for carriage traffic or 20 feet if such streets be made for foot traffic only.

PROVISIONS CONCERNING PRIVATE STREETS.

302 Notice of intention to lay out *new private streets* to be given to the Municipal Commissioner.

303 Level, direction, width and means of drainage of *new private streets* and of the buildings on either side thereof to be determined by the Municipal Commissioner.

Section

305 Levelling and draining of private streets.

306 Power to declare private streets when sewered, &c., to be public streets.

316 Prohibition of tethering of animals in public streets.

333 Manner of laying gas pipes; (gas pipes should be at the greatest possible distance from water pipes and gas pipes shall be laid above the water pipe when it is necessary for a gas pipe to cross a water pipe).

335 Buildings, &c., not to be erected without permission over Municipal gas pipes.

BUILDING REGULATIONS.

337 Notice to be given to the Municipal Commissioner of intention to erect a building.

338 Municipal Commissioner may require plans and other documents to be furnished.

339 Municipal Commissioner may require plans, &c., to be prepared by a licensed Surveyor.

340 Additional information, &c., may be required.

341 Effect of non-compliance with requisition under section 338 or 340.

342 Notice to be given to the Municipal Commissioner of intention to make additions, &c., to a building.

343 Plans and additional information to be called for.

345 Within 30 days, the applicant must receive a reply of approval or disapproval or for production of further particulars.

347 When work may be commenced.

PROVISIONS AS TO STRUCTURE, MATERIALS, &C.

348 Buildings which are to be newly erected—

(*c*) Shall not be constructed on any site which has been filled up with excrementitious matter, &c.;

(*d*) Shall have the plinth at least 2 feet above the centre of the nearest street;

(*e*) Shall be so constructed that the whole of at least one side of every room thereof shall either be an external wall or abut on an interior open space. Such external walls except where it faces a street of not less than 15 feet in width, shall have between it and the boundary line of the owner's premises an open space, extending throughout the entire length of such wall, at least two feet wide, or in the case of a chawl or building intended to form a range of separate rooms for lodgers, at least 5 feet wide. Such interior open space shall have an area equal to not less than 1/10th of the aggregate floor area of all the rooms abutting thereon and shall not be in any direction less than

Section

6 feet across. And every open space, whether exterior or interior, required by this clause, shall be and be kept free from any erection thereon and open to the sky and shall be and be kept open to access from each end thereof;

(f) The rooms shall be in every part at least 10 feet in height from the floor to the ceiling, except a room in the roof thereof;

(g) The room in the roof of a building shall have an average height of at least 8 feet from the floor to the ceiling and a minimum height of not less than four feet;

(h) Every room shall have a clear superficial area of not less than 100 square feet;

(i) The ventilation of each room should be by doors and windows which open directly into the external air and have an aggregate opening equal to not less than ⅙th of the superficial area of the side of the room which faces an open space.

349 Roofs and external walls of buildings not to be of inflammable material.

349A Maximum height of buildings,—70 feet.

349B Height of buildings with reference to width of streets.

353A Completion Certificates; permission to occupy or use.

SANITARY PROVISIONS.

365 Cleansing of streets and removal of refuse.

367 Provision and appointment of receptacles, depots, and places for refuse, &c.

368 Duty of occupiers to collect and deposit refuse, &c.

369 Provision may be made by Municipal Commissioner for collection, &c., of excrementitious and polluted matter.

370 Collection and removal of excrementitious and polluted matter when to be provided for by occupiers.

371 Halalkhor's duties may not be discharged by private individual without Municipal Commissioner's permission.

372 Prohibition of—

(a) Failure to remove refuse, &c. (which should not be allowed to accumulate on the premises for more than 24 hours);

(b) Removal of refuse, &c., without proper precautions;

(c) Failure to clear away any refuse, &c., which drops during *removal*;

(d) Leaving filth carts, &c., unnecessarily in the streets;

(e) Throwing or placing refuse, &c., in any place not appointed for the purpose;

(f) Allowing filthy matter to flow or soak or to be thrown from any premises in such a way as to cause nuisance.

Section

373 Presumption as to offender: it shall be presumed that the offence has been committed by the occupier of a building or land, if it be shown that refuse, etc., was thrown or placed in contravention of (*e*) from that building or land.

INSPECTION AND SANITARY REGULATION OF PREMISES.

374 Power to inspect premises for sanitary purposes.

375 Cleansing and lime-washing of any building.

375A Removal of building materials which constitute a harbourage or breeding place for rats or other vermin.

376 Abandoned or unoccupied premises.

377 Neglected premises. Notice for removal of kutchra, rank vegetation, &c.

378 Buildings, U. H. H. (after inspection by Executive Health Officer and Executive Engineer).

379 Municipal Commissioner may call for a statement of accommodation, *viz.*, total number of rooms, cubic capacity of each room, &c.

379A Overcrowded dwellings—(1) Application to be made to a Presidency Magistrate who prescribes the maximum number of persons in each room and may require the owner to abate overcrowding within 10 days.

(4) A room used exclusively as a dwelling shall be deemed to be overcrowded when the floor space to each adult is less than 25 square feet or air-space less than 250 cubic feet (two children under ten years of age counting as one adult).

(5) A room *not exclusively* used as a dwelling shall be deemed to be over-crowded when the floor space to each adult is less than 30 square feet or air-space less than 300 cubic feet (two children under ten years of age counting as one adult).

380 Insanitary huts and sheds.

381 Filling in of pools, wells, ponds, quarry holes, drains or water courses or low ground which are a nuisance.

381A (1) Digging or constructing well, tank, pond or fountain.

(2) Requisition to fill in or demolish well, etc.

382 Dangerous quarrying may be stopped.

383 Removal and trimming of trees, shrubs and hedges.

384 Prohibition as to keeping animals: No person

(1) (*b*) Shall keep any animal on his premises so as to be a nuisance or dangerous to any person;

(*c*) Shall feed any animal upon excrementitious matter, dung, stable refuse, &c.

(2) Any swine found straying may be destroyed.

Section

384A Stabling animals or storing grain in dwelling houses may be prohibited.

385 Removal of carcasses of dead animals.

REGULATION OF PUBLIC BATHING, WASHING, &c.

386 Places for public bathing, &c., to be fixed by the Municipal Commissioner.

387 Regulation of use of public bathing places, &c.

388 Prohibition of bathing, &c., contrary to order or regulation.

389 Prohibition of corruption of water by steeping therein animal or other matter, &c.

REGULATION OF FACTORIES, TRADES, &c.

390 Factory, &c., not to be allowed to be worked without Municipal Commissioner's permission.

391 Furnaces used in trade or manufacture to consume their own smoke.

392 Sanitary regulation of factories, bake-houses, &c.

393 Prohibition of the use of steam whistle, or steam trumpet without Municipal Commissioner's permission.

394 Certain things not to be kept, and certain trades and operations not to be carried on without a license and except in conformity with the terms and conditions of such license.

395 Prohibition of corruption of water by chemicals, &c.

396 Inspection of premises used for manufactures under section 394.

397 Regulation of washing of clothes by washermen.

MAINTENANCE AND REGULATION OF MARKETS AND SLAUGHTER HOUSES.

398 What to be deemed Municipal markets and slaughter-houses.

399 Provision of new Municipal markets and slaughter-houses.

400 Municipal markets and slaughter-houses may be closed.

401 Prohibition of sale in a Municipal market without a license from the Commissioner.

402 Opening of new private markets.

403 Private markets not to be kept open without a license from the Municipal Commissioner.

404 Prohibition of sale in unauthorised private market.

405 Private markets and slaughter-houses to be paved and drained.

406 Regulations to be framed for markets and slaughter-houses.

410 Prohibition of sale of meat, fish, &c., except in a market. (This does not apply to fresh fish sold from or exposed for sale in a vessel in which it has been brought direct to the seashore after being caught at sea.)

411 Butchers and persons who sell the flesh of animals to be licensed.

Section

412 Prohibition of import of cattle, sheep, goat, &c., into the city without permission.

412A License required for dealing in milk.

413 *Inspection of places of sale, &c.*—Municipal Commissioner may enter any place where slaughter of animals or sale of flesh contrary to the provisions of this Act is suspected.

414 Provision for inspection of articles exposed for sale for human food (includes inspection of animals, carcasses, meat, poultry, game, flesh, fish, fruit, vegetables, corn, flour, ghee, milk, &c.)

415 Unwholesome articles, &c., to be seized.

416 *Perishable articles* to be destroyed, *viz.*, meat, fish, vegetables, &c., if found diseased, unsound, unwholesome or unfit for human food.

417 *Non-perishable articles* :—

(1) Any animal or any article not of a perishable nature seized under section 415 shall forthwith be taken before a Presidency Magistrate.

(2) If the Magistrate is satisfied that such animal or article is diseased, unsound, or unwholesome or unfit for human food, he may cause the same to be destroyed.

417A Penalty for representing any article (*Ghee*) to be what it is not.

PREVENTION OF SPREAD OF DANGEROUS DISEASES.

421 Medical Practitioners to give information of existence of dangerous disease.

422 Inspection of places for the purpose of preventing the spread of dangerous disease.

423 Prohibition of use for drinking of water likely to cause dangerous disease.

424 Municipal Commissioner may order removal to Hospital of patients suffering from a dangerous disease.

425 Disinfection of buildings, &c.

426 Destruction of huts and sheds, when necessary.

427 Place for disinfection may be provided.

428 Persons suffering from dangerous disease not to enter a public conveyance without notifying the existence of the same.

429 Municipal Commissioner to provide ambulances and vans for conveyance of patients.

430 Provisions as to carriage of persons suffering from dangerous disease in public conveyances.

431 Public conveyance which has carried a person suffering from dangerous disease must be disinfected.

432 Infected articles not to be transmitted, &c., without previous disinfection.

433 Infected buildings not to be let without being first disinfected.

Section

SPECIAL SANITARY MEASURES.

434 Municipal Commissioner may take special measures on outbreak of any dangerous disease (*e.g.* small-pox, foot and mouth disease amongst cattle and glanders in horses).

DISPOSAL OF THE DEAD.

435 Places for disposal of the dead to be registered.

436 Provision of new places for disposal of the dead.

437 New places for the disposal of the dead not to be opened without permission of Municipal Commissioner.

438 Governor in Council may direct the closing of any place for disposal of the dead.

439 Governor in Council may sanction the re-opening of places, which have been closed, for the disposal of the dead.

440 Burials within places of worship and exhumations not to be made without the permission of the Municipal Commissioner.

441 (*c*) No person shall carry a corpse along any street, along which the carrying of corpses is prohibited by a public notice.

(*f*) No person shall bury any corpse at a less depth than 6 feet from the surface of the ground.

(*g*) No person shall build or dig any grave at a less distance than 2 feet from the margin of any other grave or vault.

(*i*) No person shall re-open a grave or vault for the interment of a corpse without the written permission of the Municipal Commissioner.

VITAL STATISTICS.

442 Appointment of registrars for births and deaths.

443 Registrars to reside in their respective districts.

444 Register books of births and deaths to be supplied.

445 Registrars to inform themselves of all births and deaths.

446 Information of birth to be given within seven days.

447 Information respecting finding of new-born child to be given.

448 Officers to be appointed to receive information of deaths at places for disposal of the dead.

449 Information of death to be given at the time when the corpse of the deceased is disposed of.

450 Medical Practitioner who attended a deceased person in his last illness to certify the cause of his death.

451 Preparation of register books of deaths and of mortality returns, &c.

452 Correction of errors in birth and death registers. (An error of fact or substance cannot be corrected except on the production of a declaration made before a Magistrate by two persons and certified by such Magistrate to have been made in his presence).

453 Registration of name of child or of alteration of name.

Section

TAKING OF A CENSUS.

454 to 460—Taking of a Census.

BYE-LAWS.

461 The Corporation may make bye-laws with respect to—

(a) Construction, maintenance, &c., of drains, cesspools, water-closets, privies, urinals, &c.;

(b) Water-supply;

(c) Structure of walls, &c.

(d) Provision and maintenance of sufficient open space for ventilation of buildings;

(e) Provision of house-gullies;

(f) Control and supervision of all dangerous and offensive trades.

(g) Construction, &c., of milch-cattle stables;

(h) Cleanliness, &c., in dairies;

(j) Notice whenever any milch animal is suffering from any dangerous disease;

(k) Inspection of markets, slaughter-houses, &c.;

(l) Control and supervision of butchers;

(m) Regulations for Municipal markets, &c.;

(p) Regulations for places for disposal of the dead;

(q) For accurate registration of births and deaths.

462 Punishment may be imposed for breach of bye-laws.

463 Bye-laws must be confirmed by Government.

PENALTIES.

471 Prescribes penalties.

472 Continuing offences to be punished after first conviction with a daily fine.

473 Offences punishable under the Penal Code.

474 Punishment for acquiring share or interest in contract, &c., with the Corporation.

475 Punishment of offences against section 267.

476 Punishment of offences against section 391.

477 Extent of penal responsibility of agents and trustees of owners.

479 (3) Licenses and written permissions may be suspended or revoked by the Municipal Commissioner.

482 Consent, &c., of Commissioner may be proved by written document under his signature.

SERVICE OF NOTICES, &C.

483 Notices, &c., to be served by persons authorised by the Municipal Commissioner.

484 Service of notices, &c., how to be effected on owners of premises and other persons.

Section

485 Service of notice, &c., on "owner" or "occupier" of premises how to be effected—

(a) By giving or tendering the said notice, &c., to the owner or occupier;

(b) If the owner or occupier is not found, by giving or tendering the said notice, &c., to some adult male member or servant of the family of the owner or occupier;

(c) If none of the means aforesaid be available, by causing the said notice, &c., to be affixed on some conspicuous part of the building or land to which the same relates.

486 The three last sections (483, 484 and 485) are inapplicable to Magistrates' summonses.

487 Signature on notices, &c., may be stamped.

POWER OF ENTRY.

488 Municipal Commissioner, &c., may enter any premises for purposes of inspection, survey or execution of necessary work.

ENFORCEMENT OF ORDERS TO EXECUTE WORKS, &C.

489 Works, &c., which any person is required to execute may in certain cases be executed by the Municipal Commissioner at such person's cost.

RECOVERY OF EXPENSES BY THE COMMISSIONER.

491 Expenses recoverable under this Act shall be payable on demand; and, if not paid on demand, may be recovered as an arrear of property tax.

492 If the defaulter is the owner of premises in respect of which expenses are payable, the occupier to be also liable for payment thereof.

499 In default of owner, the occupier of any premises may execute required work and recover expenses from the owner.

500 Limitation of liability of agent or trustee of owner.

507 Remedy of owner of building or land against occupier who prevents his complying with any provision of this Act.

508 Power to summon witnesses and compel production of documents.

PROCEEDINGS BEFORE MAGISTRATE.

513 Cognizance of offences by Presidency Magistrates.

514 Complaints of offences shall be made before Magistrates within three months next after the commission of such offence.

515 Complaint by any person concerning nuisances may be made to a Magistrate.

516 Offenders against this Act may in certain cases be arrested by Police Officers.

Section LEGAL PROCEEDINGS.

517 Provisions respecting institution, &c., of Civil and Criminal actions and obtaining legal advice.

521 All Municipal servants are public servants within the meaning of section 21 of the Indian Penal Code.

522 Co-operation of Police for carrying into effect and enforcing provisions of this Act.

523 Computation of time. Protection of Municipal Officers or servants acting under this Act against suits.

POWERS DELEGATED TO THE EXECUTIVE HEALTH OFFICER AND STAFF.

Under section 68 of the Bombay City Municipal Act, the Municipal Commissioner empowers any of the Municipal Officers to exercise, perform, or discharge, as the case may be, several powers, duties, and functions conferred or imposed upon or vested in the Commissioner by the several sections, clauses and sub-sections of the said Act mentioned hereafter :—

Ex. H. O., ASSISTANT H.Os.,

Sections.—84 (subject to certain limitations prescribed by rules), 92, 112, 228, 234, 240, 243 sub-section (2), 246A, 248, 249, 249A, 250 sub-section (2), 251, 251B, 253, 257, 258, clauses (*a*), (*b*) and (*c*), 368, 374, 375, 375A, 377, 379, 379A, 380, 381, 381A sub-sections (1) and (2), 384A, 394, 396 sub-section (1), 410 sub-section (1), 412 sub-sections (1) and (2), 412A, 413 sub-section (1), 415, 416, 422, 424 sub-section (1), 425 sub-section (1), 427 sub-section (3), 479 sub-section (5), 488 and 517 clause (*a*).

Head Supervisor, Medical Inspectors, Supervisors, Assistant Supervisors and Assistant Sanitary Inspectors:—

Sections: 253, 374, 396(1), 412A, 413(1), 415, 424(1), 427(3), 479(5) & 488.

Veterinary Inspectors:

Sections :—374, 413(1) & 488.

Medical Assistants, Senior Overseers, Conservancy Overseers, Malaria Overseers and Milk Sub-Inspectors :—

Sections :—253, 374, 396(1), 412A, 424(1), 427(3), 479(5) & 488.

Nurses, Veterinary Overseers and Disinfecting Sub-Inspectors :—
Sections :—374 and 488.

SUMMARY OF BYE-LAWS MADE BY THE MUNICIPAL CORPORATION UNDER SECTION 461 OF THE MUNICIPAL ACT.

BYE-LAWS WITH RESPECT TO BUILDINGS.

"*Plinth*" means the portion of the external wall between the level of the street and the level of the first floor above the street, and, except in the case of stables, godowns, and buildings of the warehouse class, shall

in no part be less than 2 feet above the level of the centre of the adjacent portion of the nearest street or below such standard level as may from time to time be fixed by the Commissioner.

"*Topmost storey*" means the uppermost storey in a building, whether constructed wholly or partly in the roof or not, and whether used or constructed or adopted for human habitation or not.

"*Public building,*" except where otherwise defined, means a building used or constructed or adapted to be used, either ordinarily or occasionally as a place of public worship, or as a hospital, college, school (not being merely a dwelling house so used), hotel, restaurant (not being merely a shop so used), theatre, public hall, public concert-room, public lecture room, public exhibition-room, or as a public place of assembly or entertainment for persons admitted thereto by tickets or otherwise, or used or constructed or adapted to be used, either ordinarily or occasionally, for any other public purpose.

"*Building of the warehouse class*" means a warehouse, factory, manufactory, brewery, or distillery, or other place in which operations are conducted by mechanical power.

"*Domestic building*" means a dwelling house or an office building or other out-building appurtenant to a dwelling-house, whether attached thereto or not, or a shop or any building not being a public building, or a building of the warehouse class.

"*Dwelling-house*" means a building used or constructed or adapted to be used wholly or principally for human habitation.

"*Masonry-walled building*" means a building the external walls of which are constructed of brick, stone or other similar material, without the aid of timber, iron or steel framing.

"*Frame-building*" means a building the external walls of which are constructed of timber, iron, or steel framing, filled in or wholly or partially covered with brick, stone, iron plates, or other material, and the stability of which depends mainly upon such framing.

"*Open building*" means a shed or other structure consisting of a ground floor storey covered with a roof erected on posts without any filling between such posts, either of masonry, iron sheets, or any other materials, and no such structure shall be deemed to be the subject of, or referred to, in any of the following bye-laws save where the expression "open" building is used to denote the same.

"*Composite building*" means a building of which part is masonry-walled building, and part is either open building or frame building, or a building of which part is open building and part is frame building, to each of which classes of building, the bye-laws relating to masonry-walled building, open buildings and frame buildings, respectively, shall apply.

"*Chawl*" means a building so constructed as to be suitable for letting in separate tenements each consisting of a single room, or of two rooms but not of more than two rooms.

"*Brick*" means an artificially made block of clay or of lime and sand prepared under pressure with steam or of sand and Portland cement, each not exceeding 10 inches in length, 5 inches in breadth and 3½ inches in depth and capable of sustaining pressure of not less than 450 lbs. to the square inch.

"*Water-closet*".—(*a*) Every water-closet to be separated from any room intended to be used for human habitation by a dead wall, which shall be lined internally to a height of six feet with a smooth impervious non-absorbent coating of neat Portland cement not less than half an inch in thickness, or of glass, glazed tiles or polished marble.

(*b*) Every water-closet should have a window of not less than 3 square feet opening upon an external open space.

(*c*) The entrance to such water-closet should be through a lobby or bath-room having at least one window, or through a gallery which is entirely open to the outer air on one side.

(*d*) A water-closet should not be constructed within a distance of 3 feet from the boundary of the owner's premises, provided that this rule shall not operate to prevent a water-closet being constructed to abut on a street or service passage or open space intended to be permanently reserved as such.

"*Privy*":—

(*a*) Every privy should have on each side, except the entrance side, an open space, 3 feet in width, within the owner's own limits and open to the sky.

(*b*) The entrance gallery or communicating bridge should be at least 3 feet in width and open to the external air on both its sides and be shut off from any portion of any dwelling house by a closely fitting door.

(*c*) Every privy should have a window in one at least of the walls of not less than 3 square feet opening upon an external open space.

(*d*) Each privy should have its walls lined internally with a smooth impervious non-absorbent coating of neat Portland cement not less than half an inch in thickness or of glass, glazed tiles or polished marble to a height of not less than five feet above the floor of such privy.

CELLARS, &c.

Except with the written permission of the Municipal Commissioner no person shall construct any cellar, vault, or underground room, either under or as part of a building, or otherwise.

Paving, &c., of floors and damp-proof courses for walls—

(*a*) every water-closet, privy, urinal, washing or bathing place and water room included in such work, and wherever situate, and every portion of every ground floor and also—

(*b*) In the case of a chawl—

(*i*) every part of each floor included in such work, and

(*ii*) every communicating passage on an upper floor included in such work, and not being an external verandah, to be laid or paved with stone, slate or non-absorbent tiles laid on cement, or with asphalt, cement, koba or other durable material impervious to moisture.

Damp-proof course—In the case of masonry buildings, the owner shall provide, in each brick wall included in such work which is below the level of the lowest floor, a *damp-proof course*, which shall consist of sheet lead, asphalt, slates laid in cement, vitrified bricks or any other durable material, impervious to moisture.

Provided, however, that it shall be in the discretion of the Commissioner by order in writing to dispense with either or all of the details provided for in this bye-law in any case in which, in his opinion, this can properly be done.

Provided also, in the case of buildings other than chawls timber flooring may be allowed to be superimposed on the concrete or other impervious material.

Construction of moris.—"Every person who shall undertake construction work on a building shall construct the nahanis or moris in such building in such manner that between the joists and mori there shall be a complete slab of stone or other impervious material; if of stone the slab shall be not less than 2″ in thickness, if of reinforced concrete not less than 3″ in thickness, and if of iron not less than ½″ in thickness. Such slab of impervious material shall be inserted 1½″ into the surrounding wall and shall have a bearing to the same extent over the timber supports, the sides being made water-tight by cement to the satisfaction of the Municipal Commissioner."

Construction of Staircase.—Where the staircase is in a dwelling house, and is not otherwise ventilated, it shall be ventilated at the top by means of a window, or a ventilator or a sky-light in the roof.

With respect to the provision and maintenance of sufficient open space, either external or internal, about buildings to secure a free circulation of air, and of other means for the adequate ventilation of buildings (clause (d), section 461).

1. Every person who shall undertake construction work on a building shall, if such building is situate within either of the areas scheduled in the margin hereof, cause the whole of at least one side of every room included in such work and intended for human habitation to abut on an interior or exterior open air space of the width or dimensions, and fulfilling the conditions hereinafter prescribed for such open air spaces respectively or on an open verandah opening on to such an interior or exterior open air space as aforesaid.

(*a*) Area bounded by Rampart Row, Esplanade Road, Hornby Road, Fort Street, Mint Road, Custom House Road.
(*b*) Area bounded by Carnac Road, 1st Marine Street, Queen's Road, Lamington Road to Bellasis Road, Morland Road to Sankli Street, Parel Road to Babula Tank Road, Jail Road East, Dongree Street to 1st Chinch Bunder Road to G. I. P. Railway & G. I. P. Railway to Carnac Road.
Excluding Improvement Trust Estates.

(*a*) Every such interior open air space shall be ot a minimum width in accordance with the following scale :—

Minimum width of interior open air space throughout	*Where height of building (above the plinth) adjoining the interior open air space does not exceed*
10 feet.	22 feet.
12 ,,	33 ,,
14 ,,	44 ,,
16 ,,	55 ,,
18 ,,	66 ,,
20 ,,	Where height exceeds 66 feet

(*b*) Every such exterior open air space shall, subject as hereinafter provided, extend throughout the entire length or depth, as the case may be, of the building on the side of which such room so abuts and shall, unless the same is a street, be maintained for the benefit of such building exclusively and its minimum width shall, subject to Bye-law 4 below, be in accordance with the following scale, varying according to the variation (if any) in the height of such building where it immediately adjoins such open air space, that is to say :—

Minimum width of exterior open air space throughout	*Where height of building above the plinth does not exceed*
10 feet.	22 feet.
12 ,,	33 ,,
14 ,,	44 ,,
16 ,,	55 ,,
18 ,,	66 ,,
20 ,,	Where height exceeds 66 feet.

Provided that in determining the exterior open air space required, any neighbouring open air space which is assured by legislative enactment, or by Municipal Bye-laws, or by contract to be permanently and irrevocably appropriated as an open air space, may be treated as a permanently open air space required for the purposes of this Bye-law.

Provided further that an exterior open air space 10 feet wide within the plot on which such room is situate shall be considered sufficient for the purposes of this Bye-law if the following conditions are satisfied :—

(*a*) that at least one-fourth of the site as defined by Bye-law 2 is kept open to the sky and unbuilt upon above the first floor level, and

(*b*) that the building is not more than 44 feet high above plinth level where such building abuts on the said 10 feet wide open air space, and that if more than 44 fect high above plinth level such building is set back 1 foot for every extra 2 feet in height.

2. The following provisions shall have effect with respect to construction work on a building on land previously unbuilt upon or on which buildings of a moveable or temporary character only shall be standing or shall have stood previously or which is situated in any area of the City other than those scheduled in Bye-law 1 :—

Every person who shall undertake on such land construction work on a building including work such as is referred to in Section 342 (*a*) of the Act but not including work such as is referred to in Section 342 (*b*), (*c*), (*cc*)

or (*d*) of the Act, shall provide adequate means of access for external air on its front and rear sides and shall provide every room intended for human habitation or capable of being so used with adequate means of access for external light and air to the satisfaction of the Commissioner in accordance with the following rules :—

Definitions.

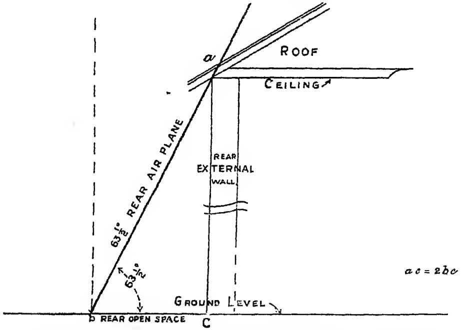
"Front air plane". I. The plane contained between the ground in front of the building and the straight lines drawn downwards and outwards from the line of intersection of the outer surface of any front wall of the building with the roof perpendicular to that line, and at an angle of 63½° to the horizontal is for the purposes of these rules described as "front air plane."

Note.—the 63½° angle has a tangent of 2 :1 ; so, if the ground is level, the air plane reaches the ground at a distance from the exterior wall equal to half the height of the wall above the level of that ground.

"Rear air plane". II. The plane contained between the ground behind the building and the straight lines drawn downwards and outwards from the line of intersection of the outer surface of any rear wall of the building with the roof perpendicular to that line, and at an angle of 63½° to the horizontal is for the purposes of these rules described as a "rear air plane." (*vide* Diagram No. 1.)

DIAGRAM No. I

SHEWING THE 63½° REAR AIR PLANE



NOTE.—THE AIR PLANE RULE REQUIRES THAT THERE SHALL BE NO ERECTION ENCROACHING ON THE AIR SPACE ABOVE THE AIR PLANE TO THE RIGHT OF THE VERTICAL DOTTED LINE.

In all cases it shall rest with the Commissioner to decide which are the rear walls of the building.

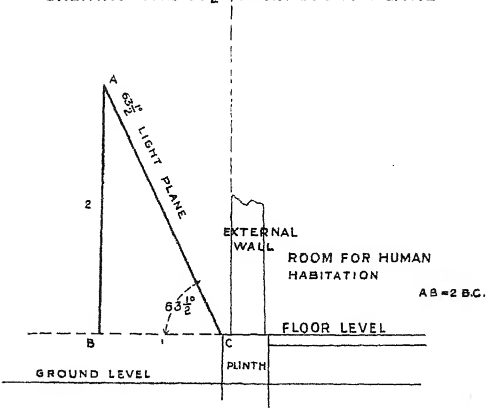
Note.—In case of the front or rear wall of a building being curved or irregular, the front or rear air plane shall be as determined by the Commissioner.

"Light plane".

III. The plane lying between the line of intersection of the floor of any room in a building with the outer surface of an exterior wall of the building and the straight lines drawn upwards and outwards from that line perpendicular thereto and at angle of 63½° to the horizontal is for the purposes of these rules described as a "light plane". (*vide* Diagram II.)

DIAGRAM No II

SHEWING THE 63½° REAR LIGHT PLANE



NOTE:—THE LIGHT PLANE RULE REQUIRES THAT THERE SHALL BE NO ERECTION ENCROACHING ON THE AIR SPACE VERTICALLY ABOVE THE LIGHT PLANE TO THE LEFT OF THE VERTICAL DOTTED LINE.

Note.—For the purposes of the above definition of light plane the outer surface of any verandah abutting on an interior or side open space shall be considered to be the exterior wall of the building.

"Permanently open air space."

IV. An air space is deemed to be permanently open if—

(*i*) it is encroached upon by no structure of any kind, and

(*ii*) its freedom from encroachment in future by a structure of any kind is assured either by legislative enactment or by Municipal Bye-laws or by contract or by the fact that the ground below it is a street or is permanently and irrevocably appropriated as an open space :

Provided that in determining the open air space required in connection with construction work on a building, any space occupied by an existing structure may be treated as if it were already a permanently open air space if it is ultimately to become a permanently open air space when this Bye-law is applied to the said existing structure or to any building to be erected on the site of the said existing structure.

"Site".

V. For the purposes of these rules, the word "site" shall include not only the land actually covered by the building, but also the land at the front, rear and sides of such building required by these rules to be left open and the words "an inseparable part of the site" shall mean that part of the site which is the property of the owner of the land on which the building stands.

"Inseparable part of the site".

Standards.

"Front and rear air space".

VI. Subject to rules VIII and IX a building is deemed adequately provided on its front and rear sides with means of access for external air, if the whole space vertically above all its front and rear air planes is a permanently open air space.

"Lighting of rooms for human habitation."

VII. Subject to Rules VIII to X a room is deemed adequately provided with access for external light for the purpose of human habitation, if the whole space, vertically above at least one of its light planes is a permanently open air space.

Minimum front, rear and side open spaces around buildings.

"Front".

VIII. No building shall be erected within 15 feet from the centre line of any street as determined by the Commissioner and every building not fronting on a street shall have a permanently open air space in front thereof not less than 15 feet wide forming an inseparable part of the site of such building.

"Rear".

IX. Every building shall have a permanently open air space in the rear not less than 10 feet in width, such air space forming an inseparable part of the site.

"Side".

X. Every habitable room not receiving its light and air from either the front or rear of a building in accordance with the $63\frac{1}{2}^\circ$ rule shall have whole of one side thereof abutting on a permanently open air space of not less than 10 feet in width.

3. Every person who shall undertake construction work on a building shall in cases not provided for under Bye-Laws 1 and 2 cause the whole or at least one side of every room included in such work whether or not such room shall be used or capable of being used or intended to be used in whole or in part for human habitation or for the purpose of domestic or other use or occupation or for the purpose of or for the carrying on therein of any trade, business or other occupation, to abut on an interior or exterior open air-space at least 10 feet in width.

Buildings built away from streets.

4. (1) Every person who shall undertake construction work, other than that described in section 342 (*b*), (*c*), (*cc*) or (*d*) of the Act, on a building situated away from a street, shall provide, in front of the said building and extending throughout its entire frontage an open air space at least half as broad as the building is high. Such open air space shall form an appurtenance of such building alone and of no other and shall be inclusive of any means of access required under these Bye-laws. In the event of any dispute as to what constitutes the front of such building the same shall be referred to the Commissioner whose decision shall be final.

Buildings more than 80 feet in depth from street line.

(2) Every building on which construction work, other than that described in section 342 (*b*), (*c*), (*cc*) or (*d*) of the Act, is undertaken and which or any portion of which comes, or, after alteration, will come within the definition of a "dwelling house" as defined by these Bye-laws, and which, or any portion of which, is distant more than 80 feet from the street nearest to such building shall so far as it lies at a greater distance than 80 feet aforesaid abut on an open air space at least half as broad as the building is high and co-extensive with the external walls of the said building and such open air space shall form an appurtenance of the said building alone and of no other and the said open space shall be provided with suitable and sufficient means of access to the satisfaction of the Commissioner.

5. No addition to a building shall be allowed unless the addition is such as would be permissible if the whole building were reconstructed from the plinth with the open spaces required under the Bye-laws appropriate to the site of the building and no addition to a building shall be allowed which would diminish the extent of open air space below the minimum which is required by the Bye-laws appropriate to the site of the building.

6. Every open space, whether exterior or interior, provided in pursuance of these Bye-laws, shall be, and be kept, free from any erection thereon and open to the sky, and no cornice, roof or weather shade shall overhang or project over the said open space so as to reduce the width to less than the minimum provided by these Bye-laws. No open drain, except for rain water, shall be constructed in any open space required by these By-laws.

Provisions as to height, dimensions and ventilation of rooms in dwellings.

7. Every person who shall erect a storey on a building intended to be used as a dwelling shall construct every room intended to be inhabited in that storey, except a room in the roof thereof, so that the same shall be in every part at least ten feet in height from the floor to the ceiling.

He shall so construct every such room in the roof of such building that the same shall have an average height of at least 8 feet from the floor to the ceiling, and a minimum height of not less than four feet.

Superficial area of rooms.

He shall so construct every such room that the same shall have a clear superficial area of not less than one hundred square feet.

Ventilation of rooms.

He shall so construct every such room that the same shall be ventilated by means of doors or windows which open directly into the external air, and have an aggregate opening equal to not less than one-fourth of the superficial area of that side of the room which faces an open space.

Through Ventilation.

8. In back to back rooms, and other single or two rooms tenements in addition to any other means of ventilation required in these bye-laws, every such room shall have a ventilator of at least 3 square feet in area near the top of each of two of the walls of such room and such ventilators shall be as far as practicable opposite to each other. In the case of upper rooms, one of such ventilators may be represented by a ridge ventilator or ventilating tiles.

Corridors in Chawls.

9. Every corridor in a chawl shall be and shall be kept open to the open air at each of its ends. Every such corridor which is more than fifty-five feet in length shall be provided at intervals of not more than fifty-five feet with an opening on both sides of the corridor of not less than five feet square communicating wholly with the open air to its full height.

The separation between the corridor and such air shafts shall be by a parapet wall not exceeding four feet in height or by an iron-railing.

With respect to the provision and maintenance of suitable means of Access to buildings (clause (dd), section 461).

10. Every person who shall erect a building shall provide as means of access to such building a pathway not less than 8 feet in width from a street to the door of such building, such pathway to be, so long as it is used as a means of access to that building, maintained free from any obstruction and shall not at any time cause or permit any portion of any building below a height of twelve feet to overhang or project over or into such passage.

He shall indicate upon any plan, required to be furnished by him under section 338 or 343, the whole area of such means of access by a distinguishing colour and description.

He shall not at any time erect or cause or permit to be erected or re-erected any building which in any way encroaches upon or diminishes the area so set apart for this purpose.

The space so set apart shall be separately distinguished from any house-gully or open space required to be provided under any other bye-law made under this Act.

11. A person who shall undertake construction work on a building shall not reduce the access to any building previously existing below the minimum width of eight feet.

12. The means of access under these bye-laws shall not be deemed to be suitable and sufficient until they have been approved by the Commissioner who shall have power to prescribe the street with which they shall communicate.

13. Every person who shall commit any breach of any of the foregoing bye-laws shall be punishable with fine which may extend to twenty rupees, and in the case of a continuing breach, with fine which may extend to ten rupees for every day after conviction for the first breach or after receipt of written notice from the Commissioner to discontinue the breach, during which the breach continues.

Penalties.

14. Whenever, under any of the foregoing bye-laws the doing or the omitting to do a thing or the validity of any thing depends upon the sanction, permission, approval, order, direction, requisition, notice or satisfaction of the Commissioner, a written document signed by the Commissioner or by any Municipal Officer to whom the Commissioner may have delegated his powers, duties or functions, in that behalf, purporting to convey, or set forth his sanction, permission, approval, order, direction, requisition, notice or satisfaction, shall be sufficient *prima facie* evidence of such sanction, permission, approval, order, direction, requisition, notice or satisfaction.

Evidence of exercise of power, duties or functions.

15. Notwithstanding anything in the foregoing bye-laws, it shall be in the discretion of the Commissioner by written permission—

(*a*) to permit any of the dimensions prescribed by any such bye-law to be modified in respect of a building ; or

(*b*) to exempt from the operation of the said bye-laws, or any of them, any temporary structure intended to stand for a shorter period than three months ;

but subject in each case to such conditions, if any, as he may think proper to attach to such permission or exemption.

Under Section 461 *clause (f).—Summary of Bye-laws for the control and supervision of premises used for offensive trades, &c., under section* 394 *of the Act.*

1. Written application to be made by the applicants for licenses.
2. Owners to furnish the names of occupants.
3. License-holders to afford facilities for examination of premises.

4

Premises used for manufacturing, &c., cloths in indigo or other colours :—

4. License-holders not to store materials not required for immediate use.
5. To adopt the best means of rendering vapours innocuous.
6. To cleanse premises daily.
7. To keep floors, &c., in good repair.
8. To keep drying ground free from hollows, &c.
9. To maintain drainage in good order.

Premises used for manufacturing, &c., blood, bones, candles, cat gut, fat, manure, meat, offal, oil-cloth, soap and tallow :—

10. License-holders to cause premises to be cleansed daily and cause refuse fragments to be collected and removed.
11. All receptacles to be kept clean.
12. To store materials not required for immediate use so as to prevent emission of affluvia.
13. To adopt best means of rendering vapours innocuous.
14. To keep all internal surfaces of walls and floors in good order.
15. To lime-wash the interior twice a year or oftener.
16. To maintain drainage in good order.
17. To maintain ventilation in good order.
18. To adopt and maintain appliances, &c., for preventing nuisance.
19. Buildings used for storing not to be inhabited.

Premises used for preparing hides or skins :—

20. Premises to be swept daily, and hair, flesh, &c., to be collected and removed.
21. To cause implements and apparatus to be kept clean.
22. To cause waste lime to be removed from premises with proper precautions.
23. To cause walls to be scraped or otherwise cleansed periodically and interior to be lime-washed.
24. To cause walls and floors to be kept in good repair to prevent absorption of noxious matter.
25. To maintain drainage in good order.

Premises used for storing or pressing hides or skins :—

26. To lime-wash the interior periodically.
27. To maintain ventilation in good order.
28. Buildings used for storing not to be inhabited.
29. These do not apply to the storing of properly tanned and dressed leather.

Premises used for manufacturing, &c., cotton refuse or seed, fins, fish, horns, hoofs, hair, rags and wool, etc. :—

30. Premises to be kept thoroughly clean.
31. The interior to be lime-washed periodically.

32. To maintain drainage in good order.
33. To maintain ventilation in good order.
34. To adopt and maintain appliances, &c., for preventing nuisance.
35. Buildings used for storing not to be inhabited.
36. License-holders to furnish names of all owners of animals stabled.
37. Dung not to be deposited so as to pollute water.
38. *Floors* to be paved so as to prevent soakage.

SUMMARY OF STABLE BYE-LAWS.

BYE-LAWS RELATING TO MILCH CATTLE STABLES.

1. A license-holder shall not at any time of the day or night keep in any one *stable or shed erected on the licensed premises a larger number* of Milch Cattle than 100.

2. A license-holder shall not use for keeping Milch Cattle any stables on the licensed premises which does not fulfil the following conditions namely :—

(*a*) its height shall be not less than twelve feet measured from the floors of stalls to the wall-plate;

(*b*) it shall have an open space of not less than fifteen feet in width all round it, such width to be measured from the outer sides of the external posts ;

(*c*) its floor surface shall be at least one foot higher than the mesne level of such surrounding open space, and its situation shall be such as to admit of its being properly drained into a drain or place legally set apart for the discharge of drainage ;

(*d*) it shall be open on all sides to such surrounding open space, but may be fitted with screens or weather boards that may be approved of;

(*e*) it shall be so constructed as to afford floor space not less than twelve-and-a-half feet in length by five feet in breadth for each cow or buffalo to be stabled therein, such space to be inclusive of space occupied by any manger, central or side drain, or central passage.

3. A license holder, &c., to give, when asked, the correct name of each person who owns any of the milch cattle and the number of milch cattle.

4. Dung not to be deposited so as to pollute water.

5. Floors to be paved so as to prevent soakage.

6. Receptacles for dung, &c., to be provided. With floor not lower than surface of adjoining ground and to be so constructed as to prevent escape or soakage of contents, and to be furnished with cover.

7. Gowlis not to sleep in stable, and lofts, &c., not to be inhabited.

8. Paved surface for washing animals to be provided.

9 Drainage to be maintained in good order.

10. Premises to be thoroughly cleansed daily.

11. Not more than four days' supply of hay, grass or straw to be stored at any one time.

12. Storage of hay, &c., not to curtail minimum space for animals.

13. No fire to be allowed near hay, &c.

14. To bring out animals for inspection if required.

Licensed premises and premises occupied by dairy men and milk sellers.

15. To provide water from Municipal main.

16. To alter (if required) licensed premises not fulfilling requirements of next succeeding bye-law as to new Dairies or Cattle sheds.

17. Regulations for construction of new dairies or cattle sheds are as follows :—

(*a*) The roof to be tiled or covered with inflammable material.

(*b*) The floor to be paved throughout with suitable impervious material.

(*c*) The stable to be fitted with manger and if necessary under the rule, to be provided with a passage between the two rows of mangers.

(*d*) The stable to be drained by an open ovoid drain.

18. Not to be within 15 feet from any street or 25 feet from any dwelling house.

19. Milk not to be sold or kept in dwelling houses, &c.

20. Internal surfaces of walls and ceilings to be lime-washed periodically.

21. Floors, counters, shelves, &c., to be cleansed.

22. Water from Municipal mains and approved wells only to be used for washing milk vessels.

U*nder clause (h).—Regulations for securing cleanliness of milk shops and milk vessels :—*

1. Milk not to be sold in dwelling-houses, &c.
2. Internal surfaces of walls and ceilings of every room, in which milk is kept or sold, to be limewashed twice at least in every year or oftener if so required by the Commissioner.
3. Milk vessels to be rinsed and thoroughly cleansed before and after use.
4. Water from Municipal mains and approved wells only to be used for washing milk vessels.

Under clause (j)—Precautions against any contagious or infectious disease :—

1. Immediate notice to be given of any outbreak of sickness, and sick animals to be segregated.
2. Sickness in a Municipal milch cattle stable should be reported in the first instance to the ramoshi in charge.
3. Milk of diseased animals not to be sold or used for domestic purposes.

4. No person suffering from dangerous or infectious disease to be permitted to sell or distribute milk.

5. No person engaged in sale or distribution of milk to come in contact or communication with diseased persons.

SUMMARY OF BYE-LAWS RELATING TO HORSE AND BULLOCK STABLES.

1. License holders shall not at any time of the day or night keep in any one stable a larger aggregate number of horses or cattle or of horses and cattle than 100.

2. A license holder shall not use for keeping horses or cattle on the licensed premises any stable which does not fulfil the following conditions namely :—

(*a*) The height in no part to be less than 12 feet.

(*b*) It shall have an open space of not less than 15 ft. in width all round it within the boundary of the licensed premises.

(*c*) It shall be open on all sides to such surrounding open space, but may be fitted with screens or weather-boards that may be approved of.

(*d*) It shall be so constructed as to afford sufficient floor space for each horse stabled therein.

(*e*) To separate each pair of animals to be stabled therein from the next pair, a permanent fixed partition being required to be provided.

(*f*) The lowest floor space of the stable to be higher than the mesne level of the surrounding open space referred to in clause (*b*) and to be suitable for drainage.

3. All open spaces around and between the stables or elsewhere upon the licensed premises to be provided with stone and drained.

4. A license holder, etc., to give when asked, the correct name of each person who owns any of the horses or cattle and the number of such animals.

5. Dung not to be deposited so as to pollute water.

6. Floors to be paved so as to prevent soakage.

7. Receptacles for dung, etc., to be provided with floor not lower than the surface of the adjoining ground and to be so constructed as to prevent escape or soakage of contents and to be furnished with cover.

8. Cartdrivers and other persons not to live or to sleep in stables and ofts, etc.

9. Paved space for washing animals to be provided.

10. Drainage to be maintained in good order.

11. Premises to be thoroughly cleansed daily.

12. Not more than 4 days' supply of hay, grass or straw to be stored at any one time.

13. No fire to be allowed near hay, etc.

14. To provide sufficient water supply from Municipal main.

15. To bring out animals for inspection if required.

16. License-holder to give immediate intimation about any outbreak of infectious disease, seggregation of sick animals, etc.

17. The stable to be fitted with manger and if necessary under the rules, to be provided with a passage between the two rows of manger.

18. Not to be within 15 feet from any street or 25 feet from any dwelling house.

19. Drainage work to be done in accordance with the Municipal drainage Rules.

20. Plans to be submitted for any addition, extension, etc.

Under clause (p)—Bye-laws for regulating and maintaining all places for disposal of dead :—

1. A person shall not, without the previous written permission of the Commissioner, cause to be erected or put up in any burying ground under the immediate control and management of the Commissioner, any tombstone or other permanent mark showing the position of any grave.
2. No grave shall be re-opened for another interment within 12 months, when the body of a person has been buried without a coffin.
3. In case of burial in *unlined wooden coffin*, no grave shall be re-opened for another interment within 18 months.
4. In case of burial in a *coffin composed of or lined with tin*, lead or other metal, no grave shall be re-opened for another interment within a period of 7 years.
5. *Regulations for graves :—*
   (a) All graves shall be made in regular lines.
   (b) All graves should be properly filled in, &c.
6. All places for the disposal of the dead shall be kept clean and in good order.
7. No person shall retain a corpse on any premises, without burning, burying or otherwise lawfully disposing of the same, for more than 24 hours.
8. *Corpses for removal to Kerbela :—*
   (a) No such corpse shall be retained on any premises other than a registered place of burial.
   (b) No such corpse shall be retained for more than two months without Municipal Commissoner's sanction.
   (c) Every such corpse shall be enclosed in a suitable dammered box, soldered metal case, coffin, or other covering so as not to cause any nuisance, &c.
   (d) In case any such corpse shall, during the time it is awaiting removal, be found to be offensive or otherwise a nuisance, immediate steps shall be taken to have the coffin, or other

covering put into proper order in such a manner as to render the corpse completely inoffensive.

9. Coffins intended to be removed beyond the limits of the City of Bombay by sea or rail shall be protected by an outer casing or cover so as to guard against damage in transit.

10. No such coffin shall be removed beyond the limits of the City of Bombay except under a certificate of the Health Officer stating that such coffin is in fit state to be removed.

11. In Municipal burning and burial grounds, fees shall be charged according to the scale fixed.

BYE-LAWS RELATING TO MARKETS AND SLAUGHTER-HOUSES.

1. Every tenant or occupier of any shop, stall, godown, or standing in a Municipal market shall at all times afford free access thereto for purposes of inspection to the Commissioner, the Health Officer or the Superintendent, or to any Municipal Officer appointed in that behalf by the Commissioner.

2. A tenant or occupier of any shop, stall, godown, or standing in a Municipal market shall not cause or allow any goods, provisions, marketable commodities or articles to be deposited or exposed for sale in or upon such shop, stall, godown, or standing, so that such goods, provisions, marketable commodities or articles or any part thereof shall project beyond the line of such shop, stall or godown, or beyond the limits assigned to such standing so as to obstruct the passage of any person or of any goods, provisions, marketable commodities, or articles in or through the market or any part thereof.

3. Every tenant and occupier of any shop, stall, godown or standing in any Municipal market shall daily arrange his goods before the hour of 6 a.m. and shall remove or put them away, and, in the case of a tenant or occupier of a shop, stall or godown, close such shop, stall or godown before the hour which may for the time being be prescribed by the Commissioner as the hour for closing such market, so as to admit of the market being thoroughly cleansed.

4. Every tenant and occupier of any shop, stall, or godown in a Municipal market shall cause the same to be kept in a cleanly condition, shall allow no refuse or garbage to remain about it, but shall cause the same to be put in a tub, box, or basket and to be carried to the proper receptacle.

No person shall waste the water supplied in any Municipal market by the Corporation.

5. Every tenant and occupier and every servant of a tenant or occupier of any shop, stall, godown or standing in any Municipal market shall at all times be decently and properly dressed when present

in the market; and no tenant or occupier of a stall at which meat or fish is sold shall sit in or upon his stall so as to be in contact with such meat or fish.

6. No person shall bring any dog, or knowingly permit any dog to follow him, into any Municipal market.

7. No person shall in any Municipal market smoke, spit the juice of "pan-supari", or wilfully or negligently throw or drop in or upon any avenue or passage of such market or any of the immediate approaches thereto, any orange peel, vegetable substance, or other matter whatsoever to the danger or damage of any person.

8. No person shall loiter or stand in any of the avenues or passages of any Municipal market or its immediate approaches to the annoyance or obstruction of any person.

9. No person shall remove any meat or offal from any Municipal market without first wrapping the same up in cloth or paper so that it shall not be exposed to the public view.

10. No person shall sleep in or on any shop, stall, godown, or other place within the limits of any Municipal market.

11. No person shall ply for hire as a helkari or cooly in any Municipal market unless he be in the service of a tenant or occupier of some shop, stall, godown or standing in such market, or be brought into such market by a person resorting thereto for the purpose of purchasing therein.

12. Every person plying for hire as a helkari or cooly as aforesaid shall wear a badge on the sleeve on his left arm granted to him by the Superintendent, for which a deposit of Re. 1 will be required, together with the name and address of the holder to be entered in a register kept for the purpose, and such badge may be withdrawn at any time.

13. Every person to whom a license has been or may be granted by the Commissioner, under Section 403 of the Act, to keep open a private market, shall cause such market to be properly lighted to the satisfaction of the Commissioner by gas or oil lamps or electricity from sunset until the hour which may for the time being be prescribed by the Commissioner as the hour for closing such market.

14. Every person to whom a license has been or may be granted by the Commissioner, under Section 403 of the Act, to keep open a private market, shall comply with the following regulations for securing and maintaining such market in a proper sanitary condition:—

   (a) He shall twice at least in every year, and oftener if required so to do by the Commissioner, cause the said market to be limewashed both internally and externally to the satisfaction of the Commissioner.

(b) He shall once at least in every two years, and oftener if required so to do by the Commissioner, cause all wood-work or iron work in the building of the said market to be painted to the satisfaction of the Commissioner.

15. A person bringing an animal intended for slaughter to the Municipal slaughter-houses at Bandra shall present such animal for inspection to the Superintendent or his Assistant at the fair ground attached to the said slaughter-houses (and which forms part of the slaughter-house premises) at least 48 hours before the time at which such animal is intended to be slaughtered, and shall pay the fair ground fee for such animal according to the scale for the time being in force.

16. The Superintendent or his Assistant for the time being in charge at the fair ground shall inspect and examine every animal so presented, and shall cause to be branded with some distinctive mark (but in such manner as not to cause pain) every such animal which he may consider fit to be slaughtered for human food.

17. An animal so marked will, on payment of a slaughter and carrying fee at the rate for the time being in force, be admitted for slaughter into the inner yard of the slaughter-houses, provided that no animal shall be permitted to pass into the inner yard of the slaughter-houses at a later hour in the day than 5 p.m. during the period from 1st October to 28th February, or than 5-30 p.m. during the period from 1st March to 30th September.

18. The Superintendent or his Assistant whose duty it is to inspect any animal presented for inspection shall reject any such animal as for any reason may appear to him unfit to be slaughtered for human food. The owner of an animal so rejected shall cause it to be forthwith removed from the slaughter-house premises.

19. A person shall not under any circumstances pass or attempt to pass into the inner yard of the slaughter-houses any animal which has not been inspected and branded as fit for slaughter (as aforesaid) under Bye-law 16.

20. Any animal which has not been branded as aforesaid found within the inner yard of the slaughter-houses will forthwith be removed from the slaughter-house premises, and if it appears to be diseased, unsound, or unfit for human food, will be dealt with pursuant to the provisions of Sections 415 and 417 of the Act.

21. Should the carcass of an animal which has been inspected and branded as aforesaid be found after slaughter to be diseased, unsound, or otherwise unfit for human food, it will, notwithstanding the animal was so branded, be dealt with pursuant to the provisions of Section 416 of the Act. All fees paid in respect of the animal, except the slaughter-fee in the case of animals slaughtered, will be refunded on application to the Superintendent.

22. A person bringing a pig intended for slaughter to the Municipal slaughter-house for pigs at Sonapore shall present such pigs for inspection to the Superintendent, or his Assistant in charge, at the slaughter-house who shall inspect and examine every pig so presented, and shall pass every such pig as he may consider fit to be slaughtered for human food. A pig so passed will, on payment of such slaughter-fee as may from time to time be fixed by the Commissioner with the approval of the Standing Committee, under the provisions of Section 407 (*a*) of the Act, be admitted for slaughter in the said slaughter-house. Provided that no slaughtering shall, without the previous special permission in writing of the Commissioner, be permitted in such slaughter-house except at night between the hours of snnset and sunrise.

23. (*a*) A tenant or occupier of any shop, stall, godown, or standing in a private market shall not for any longer time or in any other manner than shall be reasonably necessary for the conveyance of any goods, provisions or maketable commodities to or from such shop, stall, godown, or standing, or any part of such market, place or deposit or cause or allow to be deposited in any passage or place adjoining such shop, stall, godown, or standing or elsewhere in such market, or in any of the immediate approaches thereto, any hamper, crate, basket, box, barrel, or other receptacle for any goods brought into such market for the purpose of sale or of exposure for sale.

(*b*) A tenant or ocupier of any shop, stall, godown, or standing in such market shall not cause or allow any goods, provisions, marketable commodities, or articles to be deposited or exposed for sale in or upon such shop, stall, godown or standing so that such goods, provisions, marketable commodities, or articles, or any part thereof shall project beyond the line of such shop, stall, or godown, or beyond the limits assigned to such standing, so as to obstruct the passage of any persons or of any goods, provisions, marketable commodities, or articles in or through the market or any part thereof.

(*c*) Every tenant and occupier of any shop, stall, or godown in such market shall cause such shop, stall, or godown to be kept in a cleanly condition, and shall allow no refuse or garbage to remain about it, but shall cause the same to be put into a tub, box, or basket, and to be carried to the proper receptacle.

24. Every person to whom a license has been or may be granted by the Commissioner, under section 403 of the Act, to keep open a private market shall cause or procure to be laid into the premises a water-connection of not less than one inch in diameter from the Municipal water main, and shall cause such connection and all fittings thereof to be kept at all times in proper order and efficient action so as to provide for use on the premises a sufficient

supply of water for the purpose of thoroughly washing and cleansing the premises.

He shall cause all filth, garbage and refuse which may be produced or may accumulate in any part of such market to be promptly removed, in such a manner and with such precautions as not to create a nuisance in the process of removal, to such public receptacle, depot, or place as may for the time being be provided or appointed by the Commissioner for the temporary deposit thereof.

He shall cause such market to be thoroughly swept and cleaned to the satisfaction of the Commissioner each morning and evening, and to be washed down every evening.

He shall cause every stall or bench, on which articles of food or drink are kept or exposed for sale, to be thoroughly cleansed daily and every board or place on which meat or fish is kept to be scraped.

5. Every person to whom a license has been or may be granted by the Commissioner to keep open a private market shall observe and comply with the following regulations for the proper ventilation of such market:—

(a) A clear open space of not less than 30 feet in width shall be maintained around the market.

(b) At least one entrance of not less than 10 feet in width shall be maintained in front of the market if the said market does not exceed 60 feet in length in front; if it exceeds that length, then at east two entrances, each of not less than 10 feet in width, shall be maintained.

(c) In all cases in which gates are provided to any entrance to the market, such gates shall be constructed of iron work or open wood-work.

(d) The entrances shall be so placed as to secure a free circulation of air throughout the market.

(e) The walls of roof columns shall not be less than 20 feet in height from the floor of the market to the wall plate, or tie bar, and no lofts or other similar structures shall be erected under the roof.

(f) The roof shall have ridge ventilation throughout their length and shall be fitted with movable louvre boards or shutters which can be closed in wet weather.

(g) In the space between each roof truss and under the projecting eaves of gutter way, an opening shall be kept at the top of the wall for not less than half the length of the space and not less than 18 inches deep. This opening may be grated or covered with wire netting to keep out birds.

(h) If the market has brick or masonry built walls, there shall be in every 10 feet of wall length at least one window of not less than 8 feet in height by 4 feet in width, and such windows shall be not less than 8 feet above the floor level.

(i) If the market is supported on pillars and has open sides fitted with shutters, such shutters shall be so arranged and fitted as not to obstruct ventilation.

26. Passages or spaces not less than 8 feet in width shall be maintained between the rows of stalls or benches in each market.

The following are the Sections of the Bombay District Municipal Act of 1901, corresponding to those of the Bombay City Act :—

———	District Municipal Act Sections.	Bombay City Act Sections.
Definitions	3	3
Power to make Bye-laws	48	461
Obligatory Duties of Municipalties	54	61
Powers of Expenditure of Municipalties ..	56	63
Taxes to be imposed	59	139
Publication of sanctioned rules with notice ..	62	466–467
Power to fix a special rate in lieu of special sanitary cess	71 (2)	172
Powers to require repairs, etc., to private streets and to declare such streets public streets	90 (3) 90 (4)	305
Notice of intention to erect new buildings ..	96	337
Right to proceed with new buildings if no reply received within one month	96 (4)	345
Definitions of "to erect a building"	96 (6)	337(2)
Municipal control over drains	99	220
Powers for making drains	100	222
Sufficient drainage of houses	101	228
Cesspool if no drain within 50 ft.	101 (*a*)	231–232
Powers of owners and occupiers of buildings to drain into Municipal drain	102	228
Right to carry drain through land belonging to other persons	103	230
Provision of privies	106	248
,, for workmen exceeding 20	106 (2)	249
,, for screening privy from view ..	106 (3)	250
Power of demolishing privy, etc., which is a nuisance	107 (2)	249A
Encroachments on Municipal drains ..	110 (2)	223
Inspection of drains	111	253
Execution of drainage works without allowing option	112	230
Ruinous or dangerous buildings	119	354
Powers with regard to dangerous, stagnant or insanitary sources of water supply ..	120	381
Obstructions and encroachments on public streets	122	308
Dangerous quarrying	126	382
Depositing dust, refuse, filth, etc.	127	372(*e*)
Discharging sewage	128	372(*f*)
Non-removal of filth, etc.	129	372 (*f*) & 377
Filthy buildings..	131 (1)	377
Buildings U. H. H.	131 (2)	378
Deserted or offensive buildings	131 (3)	376
Power to enter and inspect buildings.. ..	132	374

———	District Municipal Act Sections.	Bombay City Act Sections.
Using or storing offensive manure	136	377 & 372
Feeding animal on filth	137A	384(c)
Consumption of smoke	138	391
Licensing opening, closing, & letting of markets & slaughter houses	139 & 140	402 & 403
Search for and inspection of unwholesome food	142(1) (a)	412 to 415
Perishable articles to be destroyed and non-perishable to be taken before a Magistrate	142(1) (b)	416
Bombay Prevention of Adulteration Act, Ghee Act	142(2)	
Powers to be conferred for prevention of dangerous diseases	144(1) (2)	421 to 433
Duties of Municipality on threatened or actual outbreak of dangerous diseases ..	145	
Duties in respect of diseases among cattle ..	147	434
To abate overcrowding	148	379,379-A
Closing of places for the disposal of the dead	150	438
Regulation of trades	151	394
Prohibition of steam whistles	151A	393
Service of notices	154	483 to 485
Municipality may carry out works and recover expenses	156(1)	489 & 491
Improvement expenses	156(1)(b)	494
Entry for purposes of the Act	159	488
Municipality may prosecute for any public nuisance within six months next after the commission of such offence	161	514 (3months)
Power to compromise or compound	165	517
Powers of Police officers	168	522
Collector's powers of suspending execution of orders, etc., of Municipalities	174	
Governor in Council may require any City Municipality to appoint a Chief Officer, Health Officer or an Engineer	177	
Power of Government to provide for performance of duties in default of Municipality	178	
Power of Government to supersede Municipality in case of incompetency or abuse of powers..	179	
Constitution of City Municipalties	181	
City Municipality may appoint Chief Officer, Health Officer and Executive Engineer ..	182	74
Powers of Chief Officer..	183	
Chief Officer's powers of appointment and punishment	184	
Delegation of Chief Officer's powers	185	
Appointment of Municipal Commissioner ..	186(A)	54
Powers of Municipal Commissioner	186(g)	
Delegation of powers of Municipal Commissioner	186(m)	68

BOMBAY ACT No. V OF 1890.

(MUNICIPAL SERVANTS' ACT.)

Whereas *it is expedient to* make better provision in the City of Bombay and elsewhere for the enforcement of regulations regarding certain classes of Municipal servants whose functions intimately concern the public health or safety, and regarding the duties, withdrawal from duty, and leave of such servants; It is enacted as follows:—

Short Title.

1. (1) This Act may be cited as the Bombay Municipal Servants' Act.

Commencement and extent.

(2) It shall come into force in the city of Bombay at once.

(3) The Governor in Council may, by notification, extend all or any of its provisions, on and after a day not less than two months after the date of such notification, to any Municipal district in the Bombay Presidency.

He may also cancel or vary such notification consistently with the provisions of this Act.

Interpretation.

2. (1) Unless there be something repugnant in the subject or context, all words, used in this Act, shall have respectively the meanings assigned to them in the City of Bombay Municipal Act, 1888.

Act to be read with Municipal Acts in force.

(2) This Act shall, in so far as it affects the City of Bombay, be read with the City of Bombay Municipal Act, 1888, and in so far as it affects any other part of the Presidency of Bombay, shall be read with the Bombay District Municipal (*a*) Act, 1901 (*a*).

Conditions as to resignation, withdrawal and absence from specified duties.

3. (1) Any Municipal officer, servant or other person employed by, or on behalf of, the Corporation or a Municipality to perform any of the duties specified in the schedule, who—

(*a*) without the written permission, in the City of Bombay of the Commissioner or a person by him deputed in that behalf, and elsewhere of the officer authorised by the Municipality to give such permission, resigns his office without at least two-months' notice given in writing to the Commissioner or person by him deputed, or to such officer, or withdraws or absents himself from the duties thereof, except in case of illness or accident disqualifying him for the discharge of such duties or other reason accepted as sufficient by such Commissioner or person by him deputed, or such officer, or

(*b*) is guilty of any wilful breach or neglect of any provision of law or any rule or order which as such municipal officer, servant or other person employed by, or on behalf of, the Corporation or a Municipality it is his duty to observe or obey, or

(*c*) who abets an offence under clause (*a*) or clause (*b*), shall be liable to forfeit his pay accruing due under a current term of service, and arrears

of pay due for a term of not more than one month, and in addition to such forfeiture and any other penalty which may be imposed on him under any enactment or rule for the time being in force, shall be liable, on conviction by a Magistrate, to imprisonment which may extend to three months or to fine, or to both imprisonment and fine:

Provisos.

Provided that if any such officer, servant or other person produces a certificate signed by the Medical officer appointed in the City of Bombay by the Commissioner, and elsewhere by the Municipality in this behalf, of a present incapacity to perform his duties which will probably endure for a month or more, the necessary permission to resign shall forthwith be granted:

Provided further that no fee shall be taken from a person on account of such certificate as aforesaid or of examination in connection therewith.

(2) The provisions of clauses (*a*) and (*b*) of sub-section (1) shall not apply to persons at the date of the passing of this Act in the employment of the Corporation or of a Municipality until the lapse of two months from such date.

Power to dispense with two months' notice or with services after tender of resignation.

4. (1) The Commissioner or officer authorized by the Municipality under section 3 (*a*), may:

(*a*) at his discretion, accept any resignation to take effect at a time less than two months from the date thereof, or

(*b*) at any time after any Municipal officer, servant or other persons employed as aforesaid, has tendered his resignation, dispense with the services of such officer, servant or person.

(2) Any such officer, servant or other person whose services are dispensed with under sub-section (1), clause (*b*), shall, subject to any agreement in writing previously made between him and the Corporation or Municipality or its representative, be entitled, in addition to any wages which he may have earned at the date of tendering his resignation, to fifteen days' wages or to wages for such period longer than fifteen days, as his services may, after such tender of resignation, have been retained by the officer authorized in that behalf.

Power of Governor in Council to add to schedule.

5. (1) It shall be lawful for the Governor in Council on the request of the Corporation or of a Municipality from time to time, by notification, to declare that from a date to be fixed therein which shall not be less than two months from the date thereof, any specified class of duties which concern the public health or safety, shall be deemed to be included in the schedule to this Act, and from the date fixed on that behalf in such notification the provisions of section 3 shall apply to all persons employed by, or on behalf of, the Corporation or a Municipality to perform any duty of the class so specified in such notification.

(2) The Governor in Council may withdraw such notification and may from time to time cancel or vary the same consistently with the preceding

clause and with the other provisions of this Act, and may also limit the operation of any notification to any Municipality or place wherein this Act is in operation.

Copies of Act to be supplied at Nominal price to employees.

6. Every person employed by, or on behalf of, the Corporation or a Municipality to perform any of the duties set forth in the schedule, shall, on entering the service, and every person now so employed shall forthwith, receive gratis, and shall at any time thereafter, on payment of one anna, be entitled to receive in the City of Bombay from the Municipal Commissioner for the City of Bombay, and elsewhere from the President of a Municipality, a copy of this Act and of the notifications issued thereunder, applicable to such person or to the class to which he belongs, in the English, Marathi, Gujarathi, Canarese or Sindhi language.

SCHEDULE.

(*Vide Section* 3.)

Duties which render the provisions of section 3 *applicable to the persons employed by, or on behalf of, the Corporation or a Municipality to perform them.*

Class I.—Duties connected with the public health:

(*a*) scavenging or cleansing streets or premises,

(*b*) cleansing or flushing drains,

(*c*) removing or disposing of excrementitious or polluted matter from houses, latrines, privies, urinals, or cesspools,

(*d*) removing carcasses,

(*e*) preventing nuisances generally.

Class II.—Duties connected with the public safety:

Duties of—

(*a*) members of a fire-brigade,

(*b*) persons, however designated, employed on, or in connection with, the maintenance or service of any municipal water-work, drain, pumping station or fire hydrant, including—

(1) inspectors,

(2) sub-inspectors,

(3) foremen,

(4) mechanics,

(5) drivers,

(6) watchmen,

(7) labourers,

(8) workmen,

(*c*) lamp-lighters.

[*a-a*] The reference to Bombay Acts VI of 1873 and II of 1884 is altered in accordance with Bom. III of 1901, s. 2 (1) proviso (*c*).

SUMMARY OF BOMBAY ACT NO. V OF 1925.

1. *This Act* may be *called* the Bombay Prevention of Adulteration Act, 1925.

2. Definitions of food, local area and local authority.

3. Prohibition of mixing of food with injurious ingredients or selling the same.

Exemption in case of proof of absence of knowledge.

4. Prohibition of sale or manufacture for sale of food not of the proper nature, substance or quality.

Protection to persons acting in good faith.

What is or is not a good defence in prosecutions under this section.

5. Penalty for false warranty.

6. Appointment of public analyst.

7. Power to purchaser of an article of food to have food analysed.

8. Appointment of Inspector.

9. Inspector may obtain article or sample of food and submit to analyst.

10. Dealing with the article of food or sample when purchased.

Provision when article or sample is not divided.

11. Person refusing to sell food to inspector liable to penalty.

12. Offence by which magistrate triable.

13. Summons when to be applied for and what it is to contain.

14. Certificate of public analyst to be evidence of facts therein stated.

Reference to Chemical Analyser to Government.

15. Certificate of analyst other than public analyst as evidence.

16. Public analyst to attend court in person.

17. Entry for purposes of the Act.

18. *Liability for acts done in good faith in discharge of duty* or exercise of power.

19. Power to make rules for carrying out the provisions of this Act.

SANITARY ADMINISTRATION OF A PORT.

The Port Health Authority consists of a Port Health Officer, appointed and paid by Government, and his assistants, whose duties are to carry out the inspection of shipping entering and leaving the harbour, and the disinfection of ships and crews.

In exercise of the powers conferred by section 6, sub-section (1), clause (*p*), of the Indian Ports Act, 1908 (XV of 1908), as amended by the Indian Ports (Amendment) Act, 1911 (IV of 1911), and in supersession of regulations relating to dangerous, infectious or contagious diseases and the disposal of dead bodies on vessels published in Government Notification No. 5331, dated the 6th July 1915, the Governor in Council is pleased to make the following regulations in respect of the following diseases : (1) Small-pox, (2) Chicken-pox, (3) Measles, (4) Plague, (5) Cholera, (6) Yellow Fever, (7) Sleeping-sickness, (8) Typhus, (9) Scarlet fever, (10) Jigger, (11) Acute Pneumonia, (12) Influenza and (13) Cerebro-Spinal Meningitis occurring on vessels coming to or leaving ports in the Bombay Presidency (excluding Sind) and Aden or for the time being in port therein, and in respect of any

death on a vessel not carrying a medical officer coming to or leaving any port within the said area or for the time being in any port therein.

PART I.— DEFINITIONS.

In these regulations—

(1) "Health Officer" means any person appointed by Government, either by name or by virtue of his office, to be Health Officer of a port, and includes an additional or Assistant Port Health Officer and any officer appointed by Government, either by name or by virtue of his office, to perform any of the duties of a Health Officer of a port;

(2) (*a*) Except as provided in clause 1 (3) "healthy vessel" means a vessel which, even though coming from an infected port, has not had on board any death from, or any person suffering from, any of the diseases enumerated in the preamble either at the time of departure, or during the voyage from the last port of call, or on arrival;

(*b*) "Infected vessel" means a vessel which has on board one or more cases of any of the diseases enumerated in the preamble, or on board of which a case of any of those diseases has occurred either during the voyage from the last port of call or in the event of such voyage exceeding 12 days, within the twelve days or (in the case of plague and cholera seven days) immediately preceding her arrival at a port in British India;

(*c*) "Suspected vessel" means a vessel on board of which there has been a case of any of the diseases enumerated in the preamble, at the time of departure or during the voyage from the last port of call, but on board of which no fresh case of such disease has occurred within the twelve days or (in the case of plague and cholera seven days) immediately preceding her arrival.

(3) (*a*) Every vessel which has come from the East coast of Africa within the limits of port Sudan and Durban or from any other locality declared to be infected with sleeping-sickness or jigger is a "suspected vessel" for the purposes of these regulations, unless during the voyage there has been one or more cases or suspected cases of either of these diseases on board when it will be considered as "infected vessel".

(*b*) Every vessel which has within a period of two months immediately preceding her arrival started from, or touched *en route* at, a port infected with yellow fever or communicated (except orally without contact or by signal) with a vessel either infected or which has left an infected port within that period is a "suspected vessel" for the purposes of these regulations, unless within the same period there has been on board a case or suspected case of yellow fever when it will be considered an "infected vessel".

(4) The term "infected", when used with reference to any articles, includes all articles considered by the Health Officer to be infected with any of the diseases in question;

(5) The term "infected port" means any port which Government may, by notification, declare to be infected;

(6) "Master", when used with reference to a vessel, means any person (except a pilot or harbour master) having for the time being charge or control of the vessels;

(7) "Port Officer" includes any person acting under the authority of Government in charge of port discipline;

(8) "Medical Officer" (of a vessel) means any person holding medical charge of a vessel who is in possession of a certificate or diploma in medicine and surgery of a recognised university or medical school and registered in the country in which he obtained it.

PART II.—VESSELS ARRIVING AT PORTS IN BOMBAY PRESIDENCY EXCLUDING SIND AND ADEN.

2. The master of every suspected *or infected* vessel, arriving at any port, subject to these rules, shall hoist a signal which shall be—

by day the Code Flag over Flag L of the Commercial Code, which is a square flag of yellow and black borne quarterly, and

by night three lights, at a height of not less than 20 feet above the hull of the ship, which shall be arranged at a distance of not less than six feet apart, in the form of an equilateral triangle, and of which the light at the apex of the triangle shall be white and the lights at the ends of the base shall be red,

and shall report every such case or death that may have occurred from any of the causes enumerated above, or in the case of a vessel not carrying a *medical officer* any death from any cause, to the pilot or other boarding officer at the earliest opportunity, and shall also comply, on arrival at such place as may be appointed in this behalf by Government, with such regulations as may be made by Government in regard to—

(*i*) signalling the name of the port from which the vessel has come,

(*ii*) stopping at a particular place,

(*iii*) refraining from communication with the shore, and

(*iv*) taking measures for giving effect to the present regulations.

3. If the vessel be at anchor within port limits when such disease first breaks out or such death occurs, the master shall hoist the signals specified in rule 2.

4. The pilot or other boarding officer shall promptly report the circumstances of the case to the Port Officer, who shall immediately forward any report so made, or give notice of any signal hoisted, to the Port Health Officer.

5. (1) When any *healthy* vessel except as otherwise provided in clause (3) is within sight of a port in British India, the master may intimate the fact by signal.

(2) Such intimation shall ordinarily be accepted by the Port Officer and if so accepted, the Health Officer need not visit the vessel, which may be considered to have pratique.

(3) The master of a healthy vessel on which unusual mortality among rats has been observed shall hoist the signals specified in Regulations 2.

PART III.—BERTHING OF VESSELS.

6. (*a*) If the number of deaths from or cases of the diseases enumerated in the preamble, with the exception of plague and yellow fever, does not exceed two, the vessel will not be prohibited from taking up the usual place for anchorage in the harbour or port, except that she may not enter the docks without the written permission of the Health Officer, and the passengers and crew not suspected of having any of the diseases in question need not, except in the case of pilgrim and emigrant ships *and those not carrying a medical officer*, be detained on board pending the inspection of the Health Officer. The master of the vessel shall be responsible that no one of the passengers or crew, except those referred to above, is allowed to leave the vessel before inspection by the Health Officer, and shall prevent the landing of infected bedding, clothes, or other personal effects which he has reasonable cause to consider likely to be infected.

(*b*) If the number of cases or deaths within the previous twelve days has exceeded two, or when from their occurrence on pilgrim or emigrant ships or for other special reasons, further precautions may be deemed advisable, the pilot, or in his absence the master, shall keep hoisted by day or night, as the case may be, the signals prescribed by regulation 2 and shall anchor the vessel in the place appointed for the purpose and not allow any of the passengers or crew to leave the vessel except with the permission of or under such instructions as may be issued by the Health Officer.

7. If a case of yellow fever or of plague or unusual mortality among rats has occurred on board, the vessel shall not take up the usual place of anchorage pending the visit of the Health Officer; in the meanwhile the vessel shall stop at such place as Government may by order provide.

8. So long as the signals prescribed by regulation 2 are shown, no *tindal* or other person in charge of or navigating any boat shall, without the permission of the Health Officer, attempt to take it alongside such vessel.

PART IV.—INSPECTION OF VESSELS.

9. Whenever the Health Officer receives the notice referred to in regulation 4, he shall, without unnecessary delay, proceed on board and examine the vessel, and the master shall give him every facility for the examination of the passengers, crew, personal effects, cargo, and any part of the ship the Health Officer thinks necessary. The Health Officer may require

a declaration on oath from the medical officer (if any) of the vessel or from the master or from both, whether any death or sickness from an unknown or suspicious cause, or any cases of any of the diseases enumerated in the preamble, has occurred on board the vessel either during the voyage or before her departure, and with reference to plague whether any unusual mortality has been observed among rats. If the Health Officer is satisfied that such deaths as may have occurred were not due to any of the causes enumerated in the preamble, he shall permit the vessel to proceed to the usual place of anchorage and to discharge passengers and cargo, without any further restrictions. If he is not so satisfied, he shall proceed as provided in these regulations. The inspection by the Health Officer will ordinarily take place between sunrise and sunset.

10. As a result of every inspection the Health Officer shall classify the vessel as infected, suspected, or healthy, *in accordance with the definitions given in Part I.*

11. On the completion of the inspection prescribed by regulation 9, such of the passengers and crew as *have been detained under regulation* 6 (*a*) *but who* are found to be free from any of the diseases in question and unlikely to carry infection shall be allowed to land. All baggage, personal effects and cargo, except such articles as the Health Officer is entitled to disinfect, may also be landed.

12. If a case of any of the diseases enumerated in the preamble occurs on any vessel after she has entered dock or has been moored at a wharf the master shall forthwith cause information thereof to be given to the Dock Master or Superintendent of the Wharf, who shall communicate the information to the Health Officer (through the Port Officer) and to the Superintendent of Police, and shall be responsible that the sick person shall be isolated as much as possible, and that the free communication with the wharf is stopped until the Health Officer has inspected the vessel.

Part V.—Removal of the Sick.

13. When on inspection the Health Officer considers it necessary in order to prevent the spread of disease, he shall take the measures indicated in Part VI of these regulations as the case may be.

14. Unless a vessel shall have had communication with the shore under the proviso to regulation 44, and *except as provided for under regulations* 19 (2) and 34 the removal of sick passengers is not to be enforced in the case of persons bound for an onward port unless under the clearest necessity of which the Health Officer shall be the judge, and in every such case a special report explaining the reasons for the action taken must be submitted by the Health Officer to Government.

15. The Health Officer shall inform the Municipal Health Officer in all cases in which he arranges for the conveyance of a patient to a sanitarium or hospital or other place within municipal limits, and shall furnish the Municipal Health Officer with the address of any private residence to which he permits the removal of a patient.

16. Where small-pox is the disease on account of which the vessel is deemed to be infected, the Health Officer shall offer, without charge, vaccination or re-vaccination to all persons willing to be operated upon, and shall cause to be vaccinated, if their guardians or those in charge of them consent, all children below 10 years and over 6 months of age who do not bear marks of vaccination or of small-pox. In the case of plague, inoculation may similarly be offered free of charge to all willing to be inoculated.

PART VI.—MEASURES TO BE TAKEN IN THE CASE OF HEALTHY, INFECTED, AND SUSPECTED VESSELS.

17. Vessels classed by the Health Officer after inspection as healthy shall be given free pratique save as otherwise provided in rules 23 and 24. Other vessels will be dealt with in accordance with rules contained in Parts VI (A), VI (B), VI (C), VI (D) or VI (E) according to the disease on account of which they are declared suspected or infected.

PART VI-A SMALL-POX, CHICKEN-POX, MEASLES, CHOLERA, TYPHUS AND SCARLET FEVER.

18. In the event of a vessel being classed either as infected or suspected on account of any of the above-mentioned diseases, the Health Officer—

(1) shall arrange for the conveyance of any person suffering or suspected to be suffering from such disease to a sanitarium or hospital, unless the sick person or his friends can make adequate provision elsewhere of which the Health Officer must satisfy himself, but he shall not enforce the removal from the vessel of any person or persons bound for an onward port, except as provided for in regulation 14;

(2) shall either himself undertake, or direct the master of the vessel to undertake, the destruction or disinfection of all clothing, bedding and other articles that he may consider infected;

(3) may, when a vessel with one or more of the above-mentioned diseases on board has in his opinion passengers or crew in a filthy and unwholesome condition, cause the clothing and personal effects of such persons to be disinfected before allowing them to leave the vessel;

(4) may, in the case of undecked craft, direct the disinfection, or in special cases the destruction, of foodstuffs which have been exposed to contamination and are considered likely to be infected;

(5) may order that any portion of the vessel that has actually been exposed to contamination or is in a filthy or insanitary condition, or which he considers likely to be infected, should be disinfected and cleansed as he may direct and may prohibit the discharge of bilge water or water ballast within port limits without previous disinfection;

(6) may, in the case of cholera, direct the master to have the bilges and water tanks emptied and cleaned and disinfected.

PART VI-B.—PLAGUE.

19. In the case of infected vessels the following measures shall be taken :—

(1) All persons on board shall be medically examined as prescribed in regulation 9.

(2) All persons suffering from plague shall immediately be disembarked under the directions of the Health Officer and isolated in the camp or hospital, whether ashore or afloat, appointed by Government for the purpose.

(3) At the discretion of the Health Officer other persons may also be disembarked and be subjected to observation* or surveillance* or to a period of observation followed by surveillance provided that the total duration of these measures shall not exceed five days from the time of arrival.

(4) Such soiled linen, wearing apparel and articles belonging to the crew and passengers as are, in the opinion of the Health Officer, infected, shall be disinfected.

(5) All parts of the vessel which have been occupied or frequented by plague patients shall be disinfected; and any other parts of the vessel that, in the opinion of the Health Officer, are infected shall be disinfected.

(6) The rats on board shall be destroyed, either before or after discharge of the cargo, in either case as quickly as possible and in such manner as to avoid as far as possible damage to merchandise and to the ship's plating and engines. The operation, in any case, must not last longer than forty-eight hours. In the case of ships in ballast this process must be carried out as soon as possible, before embarking cargo.

(7) Passengers arriving by an infected ship and subjected to the provisions of clauses (2), (3) and (4) above are entitled to obtain from the Health Officer a certificate showing the date of their arrival and the measures taken as regards themselves and their baggage.

20. When the measures prescribed in Regulation 19 have been duly taken in respect of any vessel, the Health Officer shall by written order grant pratique, provided that, if a case of plague, or of illness suspected to be plague, occurs on board subsequent to the grant of the above certificate, the certificate shall become invalid and the vessel again become subject to the requirements of the regulations regarding infected vessels.

* "Observation" means isolation either on board the ship or in a sanitary station appointed for the purpose before the grant of pratique. Passengers under "surveillance" are not isolated; they receive pratique at once and are at liberty to proceed to their destination, but the authorities at those places are informed of their coming and they are subjected to medical examination for such period as may be fixed in these rules.

21. In the case of suspected vessels the following measures shall be taken :—

(1) All persons on board shall be medically examined as prescribed in regulation 9.

(2) The destruction of rats may be ordered at the discretion of the Health Officer, and if ordered shall be carried out in the terms of regulation 19 (6).

(3) All soiled linen, wearing apparel and personal effects of the crew and passengers which are, or are suspected to be, infected shall be disinfected.

(4) All parts of the vessel which have been occupied or frequented by plague patients shall be disinfected ; and any other parts of the vessel that, in the opinion of the Health Officer, are infected, shall be disinfected.

22. When the measures prescribed in Regulation 21 have been taken in respect of any vessel, the Health Officer shall by written order grant pratique.

23. In the case of healthy vessels other than those referred to in rule 24 pratique shall ordinarily be given at once as provided for in regulation 17, but the Health Officer may in his discretion, if special circumstances appear to him to require it, impose any or all of the following measures :—

(1) medical examination as prescribed in Regulation 9 ;

(2) disinfection of soiled linen, etc., as prescribed in regulation 19(4);

(3) destruction of rats as prescribed in regutrtion 19 (6) ; but the process of deratisation when applied in the case of a healthy ship from a plague-infected port must not occupy more than 24 hours and should be carried out in such a manner as not to interfere with the coming and going of passengers and crew between the ship and the shore.

24. In the case of a healthy vessel on which unusual mortality among rats has been observed, the following measures shall be taken :—

(1) medical examination as prescribed in Regulation 9 ;

(2) bacteriological examination of rats for plague as far and as quickly as possible ;

(3) destruction of rats as prescribed in Regulation 19(6) when considered necessary by the Health Officer or when rats are found on bacteriological examination to have plague ;

(4) in the case of rats having plague, disinfection of such parts of the ship and such articles as the Health Officer considers infected ;

(5) surveillance of passengers and crew for a period not exceeding five days from the time of arrival.

25. In exercise of the functions imposed upon him by Regulations 19 and 21, the Health Officer shall—

(*a*) attach due importance to the presence on board the vessel of a medical officer and to the provision of apparatus for disinfection by means of saturated steam and for the destruction of rats, and

(*b*) shall take into account the sanitary or insanitary, and roomy or crowded condition of the vessels.

26. If, in the case of any vessel making a passing call, the communication with the shore is restricted to the landing of passengers, mails or goods, the Health Officer may, in his discretion, enforce the provisions of Regulations 19, 21, 23 or 24 as the case may be to such extent only as may in his opinion be necessary for the purpose of controlling the actual communication with the shore.

Provided (*a*) that any persons on board the vessel whom the Health Officer has reason to believe to be suffering from plague shall be landed and kept under observation.

*Provided also (b) that ships from an infected place that have been disin*fected and have undergone adequate sanitary measures shall not, on their arrival in another port, be subjected to these measures a second time if no case has occurred since the disinfection was performed and if they have not called at an infected port. A ship which has merely disembarked passengers and their baggage or mails, without having been in communication with the shore, shall not be regarded as having called at the port.

27. The Health Officer shall whenever requested furnish the master, the ship-owner or the ship-owner's agent, with a certificate stating that measures of rat destruction have been carried out and giving the reasons why they were resorted to. Health Officers of ports visited by ships upon which periodic rat destruction is carried out, should take such certificate into account in considering whether measures under Regulation 23(3) should be imposed.

28. The foregoing regulations shall not prevent the transhipment under restrictions, to be imposed by the Health Officer in conformity therewith, of passengers, mails or goods between vessels which have not been granted pratique.

29. If any case of plague occurs among any group of persons who are being kept under observation, the patient shall be isolated or sent to a hospital, and the other persons shall continue to be detained and segregated as aforesaid for a period not exceeding five days from the date on which the group became free from plague. The clothes and effects of the patients and of such persons as have been in contact with the patient shall be disinfected at the discretion of the medical officer in charge.

30. The medical officer in charge of any place appointed for the isolation of any persons under these regulations may, in his discretion, by written order, direct that any person who is kept there under observation shall be allowed to depart and shall be subject to surveillance.

31. If the system of surveillance to which any person is subjected on shore requires his daily attendance before a medical officer, the Health Officer may, by written order, exempt such person from such attendance on being satisfied that he may be relied upon to send in a prompt report if he should fall sick.

32. Persons subjected to surveillance shall submit to, and comply with, all directions as to medical supervision or otherwise which may be given by written order of a medical officer appointed by the local Government in this behalf.

PART VI-C.—YELLOW FEVER.

33. In the case of vessels which have, within a period of two months immediately preceding their arrival, started from or touched *en route* a port infected with yellow fever or communicated (except orally without contact or by signal) with a vessel either infected or which has left an infected port within that period, the following procedure shall be observed:—

(1) The vessel shall be anchored at sea at such special anchorage as may be fixed for this purpose by the local Government but in no case less than half a mile from the land at low water. The visit of the Health Officer shall be made during the day as early as possible, and all persons on board shall be medically examined as prescribed in Regulation 9.

(2) Any person suffering from yellow fever, if in the first four days of the disease, or if there is any doubt about the duration of the disease, shall be protected from the approach of mosquitoes by means of curtains, and shall be treated on board for at least four days. Any person suffering from fever shall similarly be isolated, be protected from the approach of mosquitoes by curtains and treated on board for at least four days. All passengers in perfect health (with normal temperature, etc.) may be landed, and shall be kept under close observation for a period of at least eight days, extensible at the discretion of the Health Officer to a maximum of twelve days, special precautions being taken throughout the whole of this period to prevent mosquitoes having access to them.

(3) In no case should any person sick of yellow fever be landed during the first four days of his illness without the special sanction of Government. If such sanction is given, the most minute precautions to prevent mosquitoes reaching him shall be taken, including a mosquito-proof cabin on the launch, mosquito-proof ambulances and a mosquito-proof ward in an isolation hospital.

(4) The crew of the vessel should be required to sleep in airy places preferably on deck, and should be protected by mosquito-curtains.

(5) The ship shall be cleared of mosquitoes by the systematic fumigation,* under efficient supervision, of every cabin, store-room, alley-way and hold.

(6) All water in which mosquitoes could breed should be emptied into the sea and all drains flushed by means of a hose. The

* Sulphurous acid is probably the best gas to use.

bilge should be pumped out or oiled. The drinking water tanks should be emptied to get rid of larvæ, fresh water being taken and the tanks completely filled so as to drown any adult mosquitoes which may be present in them.

(7) Provided, if no case of yellow fever has occurred on board within two months immediately preceding the vessel's arrival, only such of the above measures in addition to those described in paragraphs (1),(5) and (6) shall be carried out as are considered by the Port Health Officer necessary in the circumstances of the case.

(8) No ship shall leave the anchorage for the purpose of taking up her berth until the measures described in paragraphs (5) and (6) have been carried out.

PART VI-D.—SLEEPING SICKNESS.

34. In the case of a vessel having on board a person suffering, or suspected to be suffering, from sleeping sickness, the person or persons shall not be permitted to land without the specific written permission of the Health Officer, who may, pending the receipt of written instructions from Government, permit the landing of such persons only if arrangements can be made for their strict isolation on shore.

In the case of Aden, the Health Officer may prevent the embarkation of or, subject to the arrangements above referred to, may disembark any person proceeding to India, who is suffering or suspected to be suffering from sleeping sickness.

35. *In the case of a vessel arriving from the East Coast of Africa within the limits of Port Sudan and Durban or from other localities declared to be infected, the procedure prescribed by rule* 2 *shall be complied with and the crew or passengers, etc, shall be medically inspected in accordance with Regulation* 9.

PART VI-E.—JIGGER.

36. In the case of a vessel having on board any person or persons suffering from jigger—

(1) the Health Officer shall carefully examine every person on board and any person or persons found to be suffering shall be removed to hospital for treatment;

(2) the clothes of infected persons shall be disinfected, and the Health Officer may, in his discretion, order the disinfection of the clothes, bedding, etc., of all persons on board;

(3) any part of the vessel likely to harbour jigger fleas shall be thoroughly washed with a watery solution of kerosine oil emulsion or in a recognised solution of tar acid which is accepted by the Port Health Officer;

(4) the ballast of such vessel, if of earth or sand, shall not be landed without the permission in writing of the Health Officer, who, if he considers it necessary, may order that it shall be discharged into the $\frac{\text{Sea}}{\text{River}}$ at such places as shall be appointed for the purpose by Government.

PART VII.—GENERAL.

VESSELS.

37. The master of any vessel coming under these regulations shall comply with all directions which the Health Officer may consider necessary under the foregoing rules.

38. The master of any vessel who may object to submit to the foregoing regulations may put out to sea again, provided that objection has been taken before there has been any communication, except by signal or through the port authorities, between such vessel and the shore or with any other vessel in port. Goods may be landed from such vessels after precautions have been taken to isolate the ship, crew and passengers and on condition that such information as the Health Officer may require regarding the mortality among rats is duly supplied; Passengers may be disembarked at their own request on condition that they submit to all the measures prescribed by the local authorities.

39. In the event of any vessel putting back to sea, the Health Officer shall intimate the fact by telegraph to the next port of call if in British India.

PERSONS.

40. All persons removed to hospital or kept under observation at any place shall obey and conform to the rules, regulations and orders for the time being in force at such hospital or place and shall be liable to pay all such charges as for the time being may, under the sanction of Government, be made against them.

41. When a suspected case of any infectious disease is removed from a vessel at any port, the Health Officer shall report the confirmation or otherwise of the diagnosis, by telegraph, to the Health Officer of the next port of call, if that port is in British India, Ceylon or the Straits Settlements. In other cases a note shall be made on the bill of health stating the nature of the suspected infectious disease and the precautions taken in connection therewith.

DEAD BODIES.

42. Disposal shall be as follows :—

(1) If death occurs on board a vessel before entering port limits, the body shall, unless there are special reasons to the contrary, be buried at sea in not less than nine fathoms of water, in such manner as shall secure its immediate sinking and remaining below the surface.

(2) If death occurs during the day on board a vessel within the port limits the ensign and house flag, if there is one, are immediately to be lowered half-mast and kept in such position from sunrise till sunset as long as the body remains on board. If death occurs between sunset and sunrise, one red light is to be hoisted at the peak, half-mast high.

(3) The master of the vessel shall cause the death of a person on board to be intimated forthwith to the police, either by letter or otherwise, and shall forward to the Port Officer a written report as soon as possible after the occurrence, in which all the circumstances attending the death must be fully detailed.

(4) No dead body shall be removed from a vessel within port limit, without the permission of the police, which shall not be given until the Health Officer has certified *either*—

(*a*) *that the death is not due to infectious disease ; or*

(*b*) *that, in case of infectious disease, the Port authorities have given permission for burial on shore.*

If the Port authorities, in consultaion with Health Officer, decide that burial on shore cannot be permitted, the body must be buried at sea in such manner as the Health Officer may direct.

DISINFECTION.

43. All disinfection prescribed by these regulations shall be carried out, unless otherwise specifically provided for, in the manner prescribed in the Appendix thereto.

PART VIII.—VESSELS LEAVING PORTS IN THE BOMBAY PRESIDENCY (EXCLUDING SIND) AND ADEN FOR PORTS BEYOND INDIA.

44. No vessel shall leave any port *which has been declared to be infected with any contagious or infectious disease* for any port beyond India until—

(1) all persons sailing by the vessel, whether as passengers or as members of the crew, have been medically examined by the Health Officer ;

(2) in the case of plague—

(*a*) all persons sailing by the vessel, either as passengers or as members of the crew (except such onward bound passengers as have not remained one night on shore and such members of the crew, *as have not remained one night on shore or* have not newly joined, who may be examined on board), have been medically examined by the Health Officer on shore by day as shortly as possible before embarkation ;

(*b*) all merchandise or articles of any sort which the Health Officer may consider to be infected with plague have been disinfected on shore previous to embarkation:

(*c*) all clothing, bedding and infected articles belonging to Asiatic and African members of the crew, not being officers, engineers or doctors, to deck and fourth class passengers and to third class passengers not entitled to cabin accommodation, which the Health Officer may consider to be infected with plague and, if the Health Officer thinks fit so to direct, all clothing bedding and infected articles belonging to passengers of any

class higher than the third and of any members of the crew have been disinfected on shore by day as shortly as possible before being placed on board;

(3) the Health Officer has given to the master of the vessel a bill of health stating that the medical examination and disinfection prescribed by this regulation have been carried out.

(4) In the case of any disease other than plague, the Health Officer may, in his discretion, enforce the provisions of clauses 2(*b*) and 2(*c*) above.

Provided that, if the vessel is only making a call at the port in question, the medical examination and disinfection prescribed by this regulation shall be made only in the case of persons joining the vessel there and article belonging to them, unless there is communication between the vessel and the shore. The Health Officer shall decide, for the purpose of this proviso what constitutes communication between the vessel and the shore. The bill of health in such cases need only take the form of an endorsement on the last bill of health held by the vessel and need only refer to the passengers and crew embarking at the port in question.

45. It shall be open to the Consular representative interested in any vessel to be present, if he so desires, at the medical examination and disinfection prescribed by Regulation 44.

46. If any vessel does not leave port *within* 24 *hours after* the medical examination made under Regulation 44, she shall not leave until—

(*a*) a fresh medical examination of the passengers and crew has been made under that regulation, and

(*b*) a fresh bill of health has been given to the master under that regulation.

Provided that such fresh examination may be conducted on board the vessel, whether or not there has been communication with the shore since the previous examination was made, and provided that if the time of departure be after sunrise on the day after that of inspection, the master of the vessel shall send the bill of health to the Health Officer to have the date of departure amended.

47. If, after a bill of health has been given to the master of any vessel and before the vessel leaves the port, any cargo or goods of any kind be placed on or taken off the vessel *except in such manner as may be directed by the Health Officer*, the vessel shall not leave the port until—

(*a*) such further medical examination and disinfection as the Health Officer may consider necessary have been made under regulation 44, and

(*b*) a fresh bill of health has been given to the master under that regulation.

provided that such further examination and disinfection may be conducted on board the vessel.

48. (1) After a bill of health has been given to the master of any vessel, no person except the pilot *or person authorised by the Health Officer* shall be permitted to embark on the vessel unless he has been medically examined by the Health Officer as prescribed in Regulation 44.

(2) If any such person is permitted to embark, the Health Officer shall amend the bill of health accordingly.

49. Port-clearance shall not be granted for any vessel, unless and until the master produces the bill of health prescribed by the foregoing regulations.

Provided that any port where, in the opinon of Government, local conditions render this relaxation advisable, the authority responsible for granting port-clearance may grant port-clearence for any vessel on receiving from the Agents of the vessel a written guarantee that a duplicate of such bill of health, signed by the Health Officer, will be furnished by them to him within forty-eight hours.

50. (1) If the Health Officer considers that any passenger is suffering from, or is in the incubation stage of, any infectious or contagious disease, he shall prevent such passenger and his or her relatives and attendant from embarking or sailing; and their baggage and personal effects shall not be allowed on board the vessel and, if already placed on board, shall be removed as early as possible.

(2) For the purposes of this regulation, the term "relatives" shall mean such persons as have been living with, or have been, in the opinion of the Health Officer, in dangerous communication with the suspected passengers.

51. (1) If the Health Officer considers that any member of the crew of the vessel is suffering from, or is suspected to be in the incubation stage of, any infectious or contagious disease—

(a) he shall prevent such member from re-embarking on such vessel and shall refuse to give a bill of health until the baggage and personal effects of such member have been removed from the vessel and such parts of the vessel as have been occupied or frequented by such member have been disinfected; and

(b) the baggage and personal effects of such persons as were in immediate contact with such member of the crew shall be disinfected and the names of such persons shall be given to the medical officer or master of the vessel for supervision on the voyage.

(2) All action taken under clause (1) of this regulation for the disinfection of a vessel shall be noted in the bill of health.

52. Any person who is prevented by the Health Officer under the foregoing regulations from embarking or sailing, may be removed to and kept at a hospital or kept under observation; or, if any such person gives a genuine address, he may, at the discretion of the Health Officer, be subjected to surveillance for a period not exceeding five days.

53. At all ports declared to be infected with plague, proper measures shall be taken to prevent rats obtaining access to vessels (Appendix B).

54. Regulations 44 to 53 shall apply to all pilgrim or emigrant ships and may, by order of Government, be applied to vessels leaving a port in India or Burma for another in India or Burma.

(*See Regulation* 43)

APPENDIX A.

INSTRUCTIONS FOR DISINFECTION.

1. Personal effects, such as rags, bandages, papers and other articles without value which, in the opinion of the Health Officer, are deemed likely to carry infection, should be destroyed by fire.

2. Underclothing, bedding, wearing apparel, mattresses, carpets, etc. which are contaminated or *suspected*, and other articles to be disinfected, should be exposed for 15 minutes to saturated steam—under pressure if possible—at a temperature of not less than 100° C. (212° F.) care being taken that the steam shall reach all parts of each article to be disinfected.

3. *Disinfecting Solutions.*

   (*a*) Solution of corrosive sublimate of 1 part in 1,000 with the addition of 2 parts in 1,000 of hydrocholoric acid or 160 grains of chloride of soda in one gallon. The solution should be coloured with aniline dye or indigo; it should not be placed in metal vessels.

   (*b*) A 5 per cent. solution of pure crystallized carbolic acid, or 5 per cent. of crude commercial carbolic acid free from tar oils in a warm solution of soft soap.

   (*c*) Freshly prepared lime-wash.*

   (*d*) Such proprietary tar acid compound as the Health Officer may approve of.

4. *Special instructions to be observed in the employment of disinfecting solution.*—The linen, clothing and articles soiled by the excreta of patients should be soaked in the solution of corrosive sublimate. The solution of pure carbolic acid and the solution of soap and carbolic acid are equally suited to the purpose. The articles should remain in the solution for at least six hours.

Articles which cannot be subjected to the temperature of 212° F. without injury, as leather goods, wooden articles stuck together with glue, felt, velvet, silk, etc., should be washed with a disinfecting solution : coins can be disinfected with the solution of soap and carbolic acid. Persons engaged in nursing the sick should wash their hands and faces with one of the carbolic solutions. The carbolic solutions will be useful more particularly for disinfecting articles such as metal or instruments which can neither be subjected to a temperature of 212° F. nor placed in contact with corrosive sublimate. Chlorinated lime is particularly recommended for disinfecting excreta. Expectorated matter should be burnt.

5. *Disinfection of ships on which plague has occurred among human beings or rats.*—All rats on board shall be destroyed by means of sulphurous anhydride or other suitable disinfectant. The cabins, etc., occupied by

*The lime-wash should contain 20 per cent. of lime, and may be prepared as follows:—Take 2 pounds of good quick-lime and slake it by moistening it gradually with about half a pint of water. When the operation is completed, the resulting powder must be kept in an air-tight vessel in a dry place.

For use the quantity of slaked lime obtained from 2 pounds of quick-lime should be placed in a convenient vessel and water added to make one gallon.

the sick or those suspected to be suffering from plague shall, at the discretion of the Health Officer, be treated with a solution of corrosive sublimate and thoroughly cleansed with soap and water. In the case of pneumonic plague, preliminary disinfection with corrosive sublimate solution shall be invariably carried out.

6. *Disinfection of the hold of an infected ship.*—The bilge-water shall be pumped out, and the hold washed with sea-water, a sufficient quantity of a solution of corrosive sublimate being subsequently thrown in at the discretion of the Health Officer. The bilge-water shall not be pumped out when the vessel is in harbour without the written consent of the Health Officer.

APPENDIX B.

MEASURES TO BE ADOPTED TO PREVENT RATS OBTAINING ACCESS TO VESSELS.

1. There shall be a space of at least three feet between any part of the vessel and the wall of the dock or wharf.

2. All ropes and hawsers connecting the vessel with the dock or wharf shall be furnished with a circular concave-convex rat-guard at least four feet in diameter fitting tightly with the concavity towards the wharf on the rope or hawsers, and so fixed that no part of the margin of the guard shall be less than 24 inches from the rope or hawser, or any other pattern of rat-guard that may be approved by Government.

3. To prevent rats reaching the ship by means of a gangway, as few gangways shall be used as possible; all gangways shall be raised at night, and a watchman shall be placed on each gangway during the day from the time the gangway is lowered until it is raised.

4. A responsible person shall be deputed by the local Government to ensure these measures being applied immediately the vessel is berthed.

CHAPTER II.

Collection, Removal and Disposal of Town Refuse.

Bombay Municipal Act.

S. 365. For the purpose of securing efficient scavenging and cleansing of all streets and premises, the Commissioner shall take measures for securing.—

(a) The daily surface cleansing of all streets in the City and the removal of the sweepings therefrom.

(b) The removal of the contents of all receptacles and depots and of the accumulations at all places provided or appointed by him under Section 367 or 368 for the temporary deposit of any of the matters specified in the said Sections.

S. 366. All matters collected by the Municipal servants or Contractors in pursuance of the last preceding Section and of Section 369 shall be the property of the Corporation.

S. 367. (1) The Commissioner shall provide or appoint in proper and convenient situations public receptacles, depots and places for the temporary deposit or final disposal of :—

(a) Dust, ashes, refuse and rubbish.

(b) Trade refuse.

(c) Carcasses of dead animals and excrementitious and polluted matter.

(2) Provided that :—

(i) The said matters shall not be finally disposed of in any place or manner in which the same have not heretofore been so disposed of, without the sanction of the Corporation or in any place or manner which Government think fit to disallow.

(ii) Any power conferred by this Section shall be exercised in such manner as to create the least practicable nuisance.

S. 368. (1) It shall be incumbent on the owners and occupiers of all premises to cause all dust, ashes, refuse and rubbish and trade refuse to be collected from their respective premises and to be deposited at such times as the Commissioner, by public notice, from time to time, prescribes, in the public receptacle, depot or place provided or appointed under the last preceding Section for the temporary deposit or final disposal thereof.

(2) Provided that the Commissioner may, if he thinks fit, by written notice require the occupier and owner or either of them of any premises, to cause all dust, ashes, refuse and rubbish, but not trade refuse, to be collected daily, or otherwise periodically, from the said premises and

deposited temporarily upon any place forming a part of the said premises which the Commissioner appoints in this behalf, and it shall be incumbent on the said occupier and owner or either of them to cause the said matters to be collected and deposited accordingly.

(3) It shall be incumbent on the owners of all premises to provide receptacles of the size to be prescribed by the Commissioner for the collection therein of all dust, ashes, refuse, rubbish and trade refuse to be collected from such premises. Such receptacles shall at all times be kept in good repair and condition and shall be provided in such number and place and retained in such positions as the Commissioner may, from time to time by written notice direct.

(4) It shall also be incumbent on the owners and occupiers or either of them, of all premises when required by the Commissioner by written notice so to do, to employ servants for the purpose of carrying out and complying with the requirements of sub-Sections (1) and (2) of this Section.

S. 369. When the Commissioner has given public notice, under clause (*a*) of Section 142, of his intention to provide in a certain portion of the City, for the collection, removal and disposal, by Municipal agency, of all excrementitious and polluted matter from privies, urinals and cesspools, it shall be lawful for the Commissioner to take measures for the daily collection, removal and disposal of such matter from all premises situate in the said portion of the City.

S. 370. It shall be incumbent on the occupier of any premises situated in any portion of the City for which the Commissioner has not given a public notice under clause (*a*) of Section 142, and in which there is not a water-closet or privy connected with the Municipal drain, to cause all excrementitious and polluted matter accumulating upon his premises to be collected and to be conveyed to the nearest receptacle of the depot provided for this purpose under clause (*b*) of Section 367, at such times, in such vehicle or vessel, by such route and with such precautions as the Commissioner, by public notice from time to time prescribes.

S. 371. In any portion of the City in which the Commissioner has given a public notice under clause (*a*) of Section 142, and in premises wherever situated, in which there is a water-closet or privy connected with a Municipal drain, it shall not be lawful except with the written permission of the Commissioner, for any person, who is not employed by or on behalf of the Commissioner, to discharge any of the duties of the Halalkhors.

S. 372. No person —

(*a*) Who is bound under Section 368or Section 370, to cause the removal of dust, ashes, refuse, rubbish and trade refuse or of excrementitious or polluted matter, shall allow the same to accumulate on his premises for more than 24 hours, or neglect to cause the same to be removed to the depot, receptacle or place provided or appointed for the purpose;

(*b*) Shall remove any dust, ashes, refuse, rubbish or trade refuse or any excrementitious or polluted matter

otherwise than in conformity with the requirements of any public or written notice for the time being in force under Section 368, or use for the removal of any excrementitious or polluted matter any vehicle or vessel not having a covering proper for preventing the escape of any portion of the contents thereof or of the stench therefrom ;

(c) Shall, whilst engaged in the removal of any dust, ashes, refuse, rubbish or trade refuse or of any excrementitious or polluted matter, fail forthwith thoroughly to sweep and cleanse the spot in any street upon which during removal, any portion thereof may fall, and entirely to remove the sweepings ;

(d) Shall place or set down in any street any vehicle or vessel for the removal of excrementitious or polluted matter or suffer the same to remain in any street for any greater length of time than is reasonably necessary ;

(e) Shall throw or place any dust, ashes, refuse, rubbish or trade refuse or any excrementitious or polluted matter on any street or in any place not provided or appointed for this purpose under Section 367 or 368 ;

(f) Who is the owner or occupier of any building or land, shall allow any filthy matter to flow, soak or be thrown therefrom, or keep or suffer to be kept therein or thereupon, any thing so as to be a nuisance to any person, or negligently suffer any privy receptacle or other receptacle or place for the deposit of filthy matter or rubbish on his premises to be in such a state as to be offensive or injurious to health.

S. 373. If it shall in any case be shown that, dust, ashes, refuse, rubbish or trade refuse, or any excrementitious or polluted matter, has or have been thrown or placed on any street or place, in contravention of clause (e) of the last preceding section, from some building or land, it shall be presumed, until the contrary is proved, that the said offence has been committed by the occupier of the said building or land.

S. 385. (1) It shall be the duty of the Commissioner to provide for the removal of the carcasses of all animals dying within the City.

(2) The occupier of any premises in or upon which any animal shall die or in or upon which the carcass of any animal shall be found, and the person having the charge of any animal which dies in the street or in any open place, shall within three hours after the death of such animal or, if the death occurs at night, within three hours after sunrise, report the death of such animal at the Municipal Health Department office of the division of the City in which the death occurred or in which the carcass is found.

(3) For every carcass so removed by municipal agency, a fee for the removal, of such amount as shall be fixed by the Commissioner, shall be paid by the owner of the animal or, if the owner is not known, by the occupier of the premises in or upon which, or by the person in whose charge the said animal died.

The cleansing of a City forms the basis of all health reforms and devolves on the Sanitary Authority.

'House refuse' is defined in the London Public Health Act, 1891, as consisting of ashes, cinders, breeze and night-soil filth, but does not include trade refuse.

In India, the term 'household and street refuse' includes all waste material from houses and shops which cannot be removed by drains, and includes very little cow-manure but large quantities of horse-stable manure and refuse, and bullock droppings, street sweepings and gully refuse, leaves, garden refuse, fruit and vegetables, old glass, tin and much paper, dead animals, etc. Indian refuse or cutchra contains very little coal or cinders.

'Trade refuse' means the refuse of any trade, manufacture or business or of any building materials.

In India decomposition is rapid, and as flies and other insects are so numerous, decomposing matter is more dangerous than in temperate and cold climates.

Diarrhœa, Dysentery, Cholera, Enteric fever, etc., are much more liable to be spread by flies conveying the germs from infected refuse.

It is always necessary to collect and convey refuse some distance, and as a rule transhipment of the refuse from carts or motor lorries to Railway wagons is necessary, and then again another unloading. All this is expensive and dangerous to health.

Various methods are adopted in cities and towns in India for the collection and removal of refuse. The actual method varies somewhat. Bullock carts are the usual form of motive power. Steam and petrol wagons have been adopted in

Bombay, Calcutta and other important cities. In Bombay the refuse thus collected is carried to Railway sidings and then hauled outside the Island and used for reclaiming land. In Calcutta and Madras, some of the refuse is thus disposed of and part of it is incinerated; in other places it is mixed with night-soil and trenched.

In London the house refuse amounts to 1¼ million tons per annum, 4—5 cwts. per head per annum, but is much heavier, bulk for bulk, than Indian refuse.

The average weight in towns away from the coal fields is 15 cwts. per 1,000 of the population per day. But in mining districts the average is 35 cwt. per 1,000 of the population per day.

BOMBAY.

The amount of refuse in Bombay including all household waste, stable manure from private stables, road sweepings, shop sweepings, office paper and garden refuse works out to 2.2 lbs. per day per head of the population, or .36 of a ton per annum, or about 7 cwts. per head per annum.

This does not include dung from milch-cattle stables during the dry months, as this is used for cow-dung cakes.

As this refuse decomposes much more rapidly than in more temperate countries, especially in the rains, it is necessary that the storage of refuse should not be allowed but that it should be removed twice a day at least.

This entails a large outlay, both in manual labour and vehicular plant, more supervision and a larger staff, as much depends on the rapidity and thoroughness with which the work is done.

The habits of the people in throwing all waste matter into the streets tend to make the work of cleansing the City more difficult, while their customs and modes of cooking and cleaning utensils increase the amount of household refuse.

COMPARISON OF AN AVERAGE SAMPLE OF A LARGE INDIAN CITY'S REFUSE WITH THAT OF LONDON REFUSE.

Article.	Bombay.	London.
Coal	.15	.35
Coke	.05	.15
Breeze & Cinders	27.60	25.55
Ash	14.80	47.00
Dust & Dirt	25.70	9.78
Paper, Straw, Fibrous Material and Vegetable matter	25.20	13.15
Rags	2.20	.40
Bones & Offal	1.60	.37
Glass, etc.	.80	.85
Crockery, etc.	.30	1.72
Metals	1.60	.68
	100.00	100.00

Separating from the average composition of refuse the combustible and non-combustible contents, the percentages are :—

Kind of article.	Bombay.	London.
Combustible	56.80	61.20
Non-combustible	43.20	38.80

During the monsoon it is generally very wet and soft; wet vegetable refuse lies so close that air cannot penetrate it to support combustion, and unless special means are employed to burn it, no satisfactory results may reasonably be expected.

COLLECTION AND REMOVAL OF REFUSE.

The practice of depositing refuse and waste material on the roadside or foot-path is common in most cities.

This is to be avoided by providing sanitary bins into which the refuse should be deposited and which should be emptied by travelling-carts twice a day.

All refuse carts should be covered, so that when full there will be no nuisance as they proceed along the streets.

The refuse thus collected can be taken either direct to the incinerator or reclamation ground or to the Railway siding. In the last case, the siding should be so arranged that the carts can tip directly into the wagons.

A Railway wagon holds 12 to 16 tons of refuse.

In Bombay the maximum amount of work a pair of well-fed bullocks can do in a day is to travel 20 miles and draw a load of 8 cwts. in a 2-wheeled or 16 cwts. in a 4-wheeled cart on a level and good road. This means loaded one way and empty for the return, and no detention for loading, *i.e.*, on return with an empty cart, they should be yoked to a cart loaded ready for removal. If the cart has to go from place to place collecting refuse, the number of trips that it makes will be less than if working with a duplicate cart. A cubic yard of house refuse in India weighs about 8 cwts. to 10 cwts. and this weight represents the capacity of a Bombay refuse cart.

In Bombay, the life of a bullock for the purposes of useful work may be taken as 5 years. Calculated on this basis the cost of haulage of this household and street refuse by bullocks is :—

		Rs.	a.	p.
(*a*)	Cost of a pair of bullocks	230	0	0
(*b*)	Feed of a pair of bullocks at Rs. 279-7-3 per annum, for 5 years Rs. 279-7-3 × 5	1,397	0	0
(*c*)	Shoeing and veterinary treatment for a pair at Rs. 60 per annum, for 5 years 60 × 5	300	0	0
(*d*)	A cart costs Rs. 445 and by taking the total number of carts (scavengering and drain) it works out to that—each pair of bullocks has two carts hence.	890	0	0
(*e*)	Repairs to (*d*) for 5 years	550	0	0
(*f*)	Stabling accommodation for (*a*) and (*d*) 15 per cent. of Rs. 550	82	0	0
(*g*)	A cart driver's pay including extra remuneration for making full number of trips at Rs. 24 plus 5 per mensem, but deducting absentees will make the average	1,740	0	0
(*h*)	Accommodation of cart drivers at 10 per cent. ..	174	0	0

The total therefore is Rs. 5,360 for 5 years, and during the period a pair of bullocks removes 2,190 tons, the cost of removal being Rs. 2-7-2 per ton.

As many as 2,590 carts are now unloaded at the Siding in Bombay daily.

Cost of unloading carts at the Siding, loading wagons and haulage and unloading of the same calculated on an average of 2,590 cart loads per day :—

130 men at Rs. 23-8 per mensem each and 17 women at Rs. 19 each per mensem, 2 Muccadums at Rs. 30 each and 2 Muccadums at Rs. 28 per mensem, 3 trip-markers at Rs. 115 each per mensem and 2 Overseers at Rs. 125 each per mensem, stores, lighting, etc., Rs. 150 per mensem, Total Rs. 4,239.

The number of trips made to the Siding daily is about 2,590, *i.e.*, 1,035 tons, or 31,050 per mensem and to unload this costs Rs. 4,239 or annas two and pies two per ton.

The haulage from Siding to reclamation ground costs Rs. 4 per wagon, *unloading* costs Rs. 7-10-0 per wagon, and as an average *of 32 carts or 14 tons* go to a wagon, 1 ton costs.

	Rs.	a.	p.
For hauling and unloading	0	10	6
For upkeep of permanent way	0	2	9
Per ton ..	0	13	3

The upkeep of a wagon costs Rs. 160 per annum and as a wagon carries *roughly 14 tons and makes one trip a day and one every alternate* Sunday (340 a year).

	Rs.	a.	p.
$340 \times 14 = 4{,}760$ tons a year.			
The cost of upkeep per ton is then	0	0	6
Summary of the cost per ton.			
Removal from Section to Siding	2	7	2
Unloading at Siding	0	2	2
Haulage to Reclamation ground and unloading there.	0	13	3
Upkeep of rolling stock	0	2	4
	3	8	11
Supervision on Rs. 3-8-11 ..	0	8	5
Total ..	4	1	4
Total cost per ton ..	4	1	4

FEED OF BULLOCKS.

In addition to grass, ooreed and moongh form the food of Cattle in parts of India. Ooreed and moongh belong to the same class as grass, *viz.*, the bean tribe. The following is their composition, which will show their nutritive value to be almost exactly alike, if anything moongh is richer in nitrogenous matter than ooreed :—

	Ooreed.	*Moongh.*
Water	11.00	9.20
Nitrogenous matter	22.48	24.70
Fatty matter	1.46	1.48
Carbo-hydrates	62.15	60.36
Salts	2.91	3.26

In some places, gram and bran are also given to the bullocks.

	Gram.	*Bran.*	*Ooreed.*
Water	10.80	13.6	11.10
Proteids	19.32	13.6	22.48
Fat	4.56	3.4	1.46
Carbo-hydrates	62.20	54.9	62.15
Salts	3.12	5.6	2.91

As a food, bran by itself is useless in spite of its chemical composition, but as an adjunct to other foods it is undeniably valuable. Both gram and bran contain a larger proportion of fat than ooreed and in the majority of dietaries fat finds a place, and when hard work is to be done an excess of fat is invariably taken. Hence gram and bran form a more nutritious food for cattle than ooreed alone.

The cost of feeding bullocks varies with the kind and price of food and the districts, size of bullocks, etc.

The daily ration of a pair of bullocks in Bombay is 10 lbs. gram soaked in water and the water drawn off, 1 lb. bran mixed with gram, and 30 lbs. of hay.

Bombay produces about 1,040 tons of refuse daily (exclusive of trade refuse and milch-cattle dung), or 292 tons per annum per 1,000 of the population, or 1.8 lbs. per head per day or .29 ton per head per annum, against 250 tons per 1,000 of the population of large English towns or 1.52 lbs. per head per day or ·25 ton per head per annum.

The amount of house refuse to be removed is much less in English cities than in India, as a great part is burnt in kitchen fires in European towns, and the labour is more easily controlled than in Indian cities.

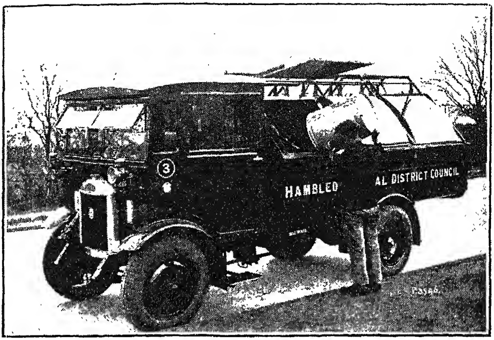
The household refuse is removed once or twice a week in English towns, while in India it should be collected twice a day, and the dust bin carts removed twice and three times a day.

In English towns large refuse carts capable of carrying one ton are drawn by horses and, accompanied by two men, pass through the streets and visit houses in rotation, weekly visits being made to each house.

The household refuse is collected and taken to the nearest depot, which is rarely a mile away, and is either burnt or put into barges and taken down the river or canal and then disposed of.

In most towns in England motor vans are used.

These motors work day and night, in the day time collecting house and street refuse and in the night watering and sweeping the streets, the body of the van being removed and replaced by a water tank.



TYPE OF LOW-LOADER USED BY THE LONDON CORPORATION AND COUNCILS IN ENGLAND FOR REFUSE COLLECTION AND REMOVAL.

During the past few years, the use of motors for Municipal work has rapidly developed.

In India one cannot immediately reduce the amount of refuse to be removed, nor the frequency of removal, but, by adopting the most cleanly and expeditious methods known, one can reduce the nuisance.

The custom in Indian towns, where no compounds exist, is for the household and trade refuse from shops, &c., to be thrown into the streets and narrow passages between the houses. They are swept and the garbage collected twice and thrice daily, deposited in the dust bin carts and removed as often as the magnitude of the staff and the strictness of supervision permit.

Sanitary dust bins should be provided and emptied twice daily.

Cleansing Work in the City of London.

The City of London contains nearly 48½ miles of streets, courts, alleys and bridges, within an area equal to one square mile. Fully seven miles of the streets may be termed main thoroughfares.

Approximately 1,250,000 persons and over 100,000 vehicles enter and leave the City each week day, and more than 380,000 persons are engaged within it daily.

38 miles of streets have both carriageways and footways. The carriageways are paved as follows :—

Asphalte 230,000 square yards; wood blocks 192,000 square yards and granite setts 64,000 square yards.

The footways, which cover an area of about 330,000 square yards, are edged with granite kerbs and paved with 84,000 square yards of asphalte and 246,000 square yards of york stone.

The present rateable value of the City is £8,841,980.

The Cleansing Department is under the control of a Superintendent and an Assistant Superintendent, and for cleansing purposes the City is divided into four districts each having one divisional and one assistant foreman, with a district staff of orderly boys, sweepers, carmen and vans.

Day Cleansing.—The out-door section consists of 396 men and boys, classified as follows :—

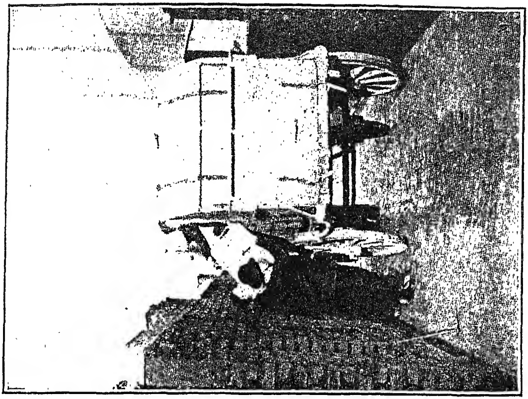
4	District Foremen.	102	Carmen and loaders.
4	Assistant Formen.	20	Motor Drivers.
169	Sweepers.	97	Street Orderly Boys.

The greater part of the day men book on at 6 a.m., but a few gangs commence work later, at various times up to 10 a.m.

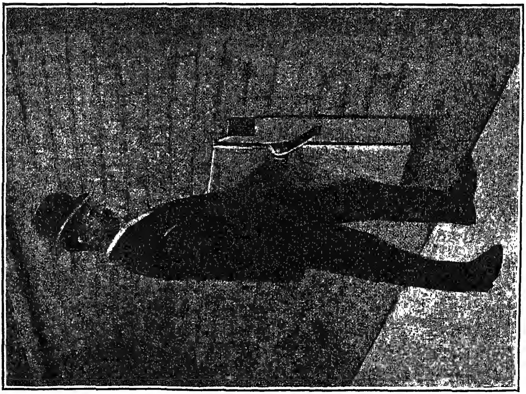
The hours are 47 per week, overtime being paid at the rate of time and a quarter for the first three hours and time and a half for the remaining period, after 47 hours have been worked.

Up to 10 a.m. about one half of the sweepers, with the necessary number of vans, etc., are employed in completing the cleansing of any streets and courts left unfinished by the night staff; or in sweeping and gravelling those thoroughfares and bridges used by early morning traffic to and from the City markets.

Simultaneously during tnese hours motor-vans and horse-vans, with their drivers and loaders, the latter being augmented by the sweepers not employed in street cleansing, are engaged in removing refuse, commencing with those premises where there are resident caretakers, or which open at a sufficiently early hour.



DUST BIN CART, LONDON.



REMOVING AN ASHBIN, LONDON.

Under Regulations made by the Ministry of Transport and the Commissioner of City Police, certain main streets are scheduled, in which no house or trade refuse shall be collected between 9 a.m. and 7 p.m., and in other secondary streets between 10 a.m. and 7 p.m.

To carry out these Regulations, the Corporation of London made certain by-laws, which were approved by the Ministry of Health, under which tenants and occupiers of premises in the schedule streets are required to deposit their refuse in metal dustbins of a capacity not exceeding $2\frac{1}{2}$ cubic feet, on the kerbstone in front of their premises before 8 a.m.

The daily average tonnage of refuse collected before 10 a.m. is approximately 120 tons, and to complete the work by the scheduled time every available van with its attendant loaders is fully employed.

After 10 a.m., the collection is continued in those streets not included in the above-mentioned Regulations.

The work of dust collection is completed by about 2 p.m. daily and by 11 a.m. on Saturday.

At 7-30 a.m. the street orderly boys, who have previously been supplied with tea at their respective depots, commence work and assist in cleansing and gravelling the streets for which purpose they are provided with scoops and brushes. In wet weather the orderly boys squeegee the footways and assist on the carriageways.

Refuse picked up by street orderly boys is deposited in street orderly bins of which there are about 350 distributed throughout the City, chiefly in main thoroughfares.

After 10 a.m., the day sweepers (except those employed in loading vans) are engaged in cleansing the main and most of the secondary streets by means of hand brooms, squeegees or scrapers, according to the condition of the carriageways. Motor sweeping machines are used when required.

After the boys cease work, a few sweepers are stationed on the most important streets until the night staff commence work.

On Bank Holidays a skeleton staff is engaged on the main thoroughfares, sweeping, gravelling or sanding as circumstances require.

All refuse is removed by vans to Lett's Wharf, which is situated on the River Thames, about half-a-mile from the nearest portion of the City boundary. It is there shot into contractors' barges, taken down the river and deposited under the controlled system of tipping on land belonging to the Corporation at Hornchurch, about 17 miles down the river.

Sacks for waste paper and other light material are provided free and are collected by arrangement.

Trade refuse is removed at a charge of 22*s.* 6*d.* per van load, 1*s.* 7*d.* per sack or 8*d.* per bushel.

Regulation sized galvanised dustbins, 16 inches diameter by 20 inches deep, are sold to tenants and occupiers at cost price.

The tonnage of refuse removed during the year ended 31st March 1932, was as follows :—

	Motor-vans.	*Horse vans.*
House and Trade Refuse and Gully slop	5,979	37,914
Manure and Street Sweepings ..	6,472	10,695
	12,451	48,609
		12,451
Total tons ...		61,060

Night Street Cleansing.—The greater part of the work of street cleansing takes place between 8 p.m. and 5 a.m. (except on Sunday nights), when the streets are comparatively free from traffic.

The night staff consists of 2 district foremen, 3 street flushers, 61 sweepers, 5 carmen and 9 motor-drivers, in addition to motor-vans, tanks, horsed-vans and motor sweeping-machines.

During the night the whole of the City is cleansed by one or other of the undermentioned methods.

On five nights a week the carriageways of all main wood-paved and some of the asphalte-paved thoroughfares are swept all over by machine brooms, which at the same time lay the dust by means of automisers.

On Thursday nights the whole of the wood-paved main line thoroughfares are watered all over by motor tanks and afterwards swept by machine-brooms.

Owing to the highly polished surface of asphalte carriageways and the clean condition of the centres, the sides only are watered in hot and dry weather. This is done on Friday nights.

In wet weather the above work is done nightly if required, according to the amount of rainfall and other circumstances.

When dry the carriageways of secondary streets are watered all over nightly and afterwards swept by machine-brooms.

The footways of many main and secondary streets are swept nightly by hand brooms as well as courts, alleys and narrow thoroughfares inaccessible to vehicles.

The refuse resulting from the above operations is picked up by horse and motor-vans, and conveyed to Lett's Wharf.

One gang of flushers is employed in flushing by jet and hose the streets in the vicinity of Smithfield and Billingsgate Markets on alternate nights. In addition, certain courts together with gullies in same are flushed.

Two gully-emptying machines are employed under contract every night. After the gullies have been emptied they

are re-sealed by water from the machines and the contents of the gullies removed to Lett's Wharf. Approximately 180 gullies are emptied nightly.

Gullies in courts and narrow thoroughfares which are inaccessible to these machines, are emptied by hand labour or flushed by hose.

Special attention, particularly during the winter months, is given to the gritting of thoroughfares in the vicinity of the City Markets and the routes thereto taken by traffic.

The work of watering and flushing is suspended or modified during frosty weather and on occasions of snowfalls.

Sewer Cleansing.—The Cleansing Department is responsible for the cleansing of 40½ miles of sewers within the City, with 205 sewer entrances, 64 flushing gates and about 14.000 inlets from house drains.

The men engaged in this work number 13, and their hours of work are 40½ per week.

Underground Conveniences.—The Underground Conveniences are under the control of the Superintendent of Cleansing and number 45, of which 15 are for women. A staff of 69 men, 2 boys and 28 women are employed.

The conveniences are open according to the requirements of the respective localities in which they are situated. The earliest hour of opening is 4 a.m., and the latest hour of closing is midnight.

Two conveniences are open day and night.

Number and Type of Vehicles.

75 Low-loading dustless horse-vans—6½ cube yards.

12 Open horse-vans—4¾ cube yards.

6 Shelvoke and Drewry low-loading dustless freighters, 2 of 6¾ cube yards and 4 of 9½ cube yards capacity, provided with interchangeable water bodies.

2 Dennis Bros. low-loading dustless motor vans, 13 cube yards.

3 Laffly motor-sweeping machines.

3 Lacre three-wheeled motor sweeping machines.

The total staff of the Department is 662.

CLEANSING WORK IN THE CITY OF BOMBAY.

The area of the City is 15,480.29 acres or 24.19 sqr. miles. The population (Census 1931) is 1,161,383. The inhabited houses 1931 are 47,045. Mean density per acre is 75. The death rate for 1932 per thousand is 19.7 by the Census population of 1931.

REMOVAL.

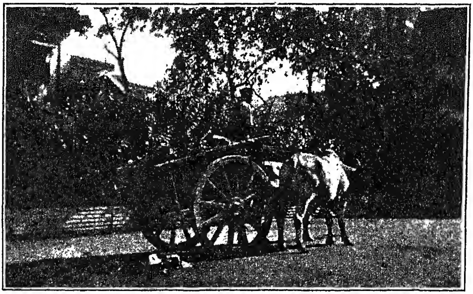
The work of the cleansing branch is conducted by the Head supervisor under the control of the Executive Health Officer. For administrative purposes the City is divided into three divisions, each under the charge of a Supervisor. These divisions are further sub-divided into 10 districts each under the charge of an Assistant Supervisor. These 10 districts are divided into 50 sections, each under the charge of an Overseer who takes his orders from the Assistant Supervisor of the district to which the section belongs.

The collection of refuse is all carried out during the day.

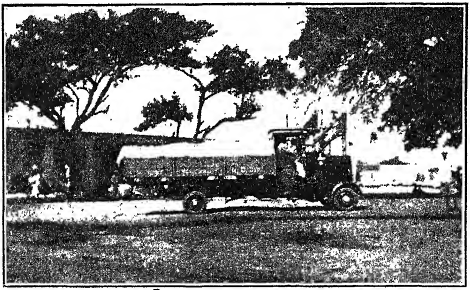
Sanitary bins of standard size and pattern are now being insisted upon by the Municipal Commissioner, on all house-owners for the storage of house refuse pending removal by the Cleansing Branch. 30,000 bins are in use at present and they are emptied out daily.

MECHANICAL TRANSPORT.

Of late years Mechanical Transport has been making great headway and is rapidly displacing bullock-carts for Municipal and Public Works. It is only therefore a matter of time before the more primitive method becomes entirely obsolete.



OLD STYLE BOMBAY.



NEW STYLE BOMBAY.

With further adoption of mechanical transport for the removal of city's refuse the system at present in vogue in Bombay during this transition period, necessitates the continuance of refuse dumps where the refuse, which had been collected by bullock-carts, is deposited and removed therefrom by means of 4-5 tons motor lorries. At present the

motor lorries are loaded at the dumps by manual labour but the question of carrying out this work by means of mechanical loaders is under consideration and is likely to be adopted. The dimensions of these lorries are 11′-7″ long by 6′-4″ broad by 3′-4″ high. Work is carried out in two shifts—the first shift being from 6 a.m. to 2 p.m. and the second from 2 p.m. to 10 p. m. The average cost of working the lorries for the year 1931-32 was 12 annas 8 pies per mile. This is inclusive of all charges such as depreciation, inspection, license fees, repairs, wages of drivers and cleaners, oil, petrol, etc.

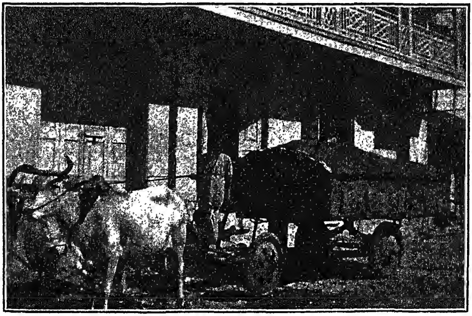
The aim of the Bombay Municipality is to eventually adopt throughout the city the system of house-to-house collection of refuse. With this object in view different types of motor transport are being tried from time to time.

A 3-ton Vulcan motor vehicle manufactured by the Company of that name at Crossens, Southport, England, has been in use for some years. This vehicle has a small engine which is economical in working and does about 15 miles per gallon. The dimensions of the body are 13′-7″ long by 6′-10″ broad by 2′-3″ high; whilst the loading height of the body from the ground is only 4′-2″. This enables the bin-man to deposit the refuse into the lorry quite easily without the assistance of a second man. These vehicles are comparatively low in initial cost and maintenance and being successful in meeting local conditions are likely to be adopted very extensively in India for this type of work. The cost for this vehicle averages 7 annas 4 pies per mile.

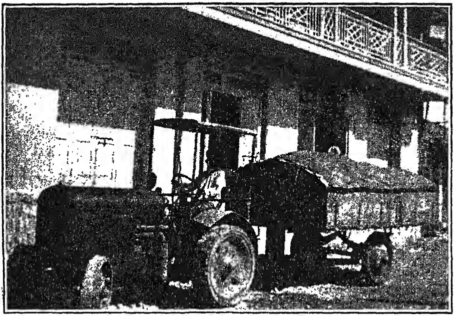
As a substitute for standing carts in one district of the city it was considered that the removal of refuse can be carried out more expeditiously if large circular bins roughly 3′ diameter, 2′-9″ high are placed in suitable positions for the reception of refuse. These bins or receptacles are fitted with a handle by means of which they can be attached to the hook of a crane with which some of the Leyland lorries are specially fitted. This enables the contents of the bins to be

rapidly emptied into the body of the vehicle; the empty bins being immediately returned to their site. This system has proved successful as it permits of the receptacles being emptied more frequently than was the case, when carts were in use. The crane on the lorry is actuated by means of a chain driven from the gear box. In Calcutta this system is extensively employed.

In 1928 a trial was given to the Tractor and Trailer system whereby suitable trailers of steel construction and having a carrying capacity of 3 tons were drawn by bullocks from house to house. After being fully loaded the trailers were taken to side lanes where the tractor called and drew the trailers either to the dumping ground or the refuse Railway Siding. Although this system at first appeared to have certain advantages, its lack of flexibility and slowness of travel together with high working cost rendered it less suitable for the purpose when the travelling distance exceeded 2 miles than the low-sided motor vehicle. For distances of 2 miles and under, the Tractor-Trailor system has been found to be both efficient and economical.



REFUSE COLLECTION COMPLETED BY TRAILER DRAWN BY BULLOCKS.



TRACTOR HAULING A LOADED TRAILER.

Leyland Steam lorries were first introduced in Bombay Municipality during the year 1911. Six of these lorries worked successfully till about 1922 when Leyland petrol motor vehicles of 4-5 ton capacity were standardized in order to ensure interchangeability of parts and to reduce the cost of repairs and maintenance.

The removal of road scrapings is carried out by means of 4-5 tons lorries fitted with steel bodies and Hydraulic tipping gear. The scrapings are thus emptied automatically. This gear is very reliable and should always be fitted when required, as by this method, emptying of the lorries is expeditiously and economically carried out.

The fleet in charge of the Conservancy Branch consists of :—

20 Lorries, 2 Crane Lorries, 4 Road Scraping Lorries and 15 Tractors with 30 Trailers.

BULLOCK CARTS.

There are 800 Scavengering carts with capacities ranging between 30-40 cubic feet and capable of taking 8 cwts. to $\frac{1}{2}$ ton of refuse each and 150 iron carts for the silt and mud of 29 cubic feet capacity each. These are all in use.

The total amount of refuse collected (including street and gully sweeping) approximates 1,040 tons per day.

This gives a weight of 16 cwts. of refuse per 1,000 of population per day or 292 tons per annum or 1.8 lbs. per head per day, or 5.8 cwts. per annum.

Trade wastes including refuse from licensed stables brought by private agency for disposal amount to an average of 233 tons per day. This added to the above figures work out to 2.2 lbs. per day per head of population or 19.6 cwts. per 1,000 of population per day or 357.7 tons per annum.

There are two collection yards, one at Palton Road and the other at Parbadevi, receiving on an average 500 and 140 cart-loads of refuse daily.

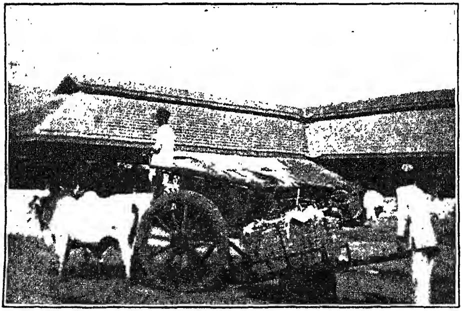
The refuse from these collection yards is loaded into petrol driven lorries and hauled to the Mahaluxmi Siding where they are unloaded into the Railway wagons and the refuse conveyed to the marshy lands at Deonar, which is being reclaimed. Deonar is 7 miles away from the city limits. Carts working outside the collection area pertaining to the two yards, go direct to Mahaluxmi Siding, excepting about 10 in the extreme northern portion of the island. These latter dump their contents at the Dharavi Reclamation Ground.

STREET CLEANSING, WASHING AND SCRAPING.

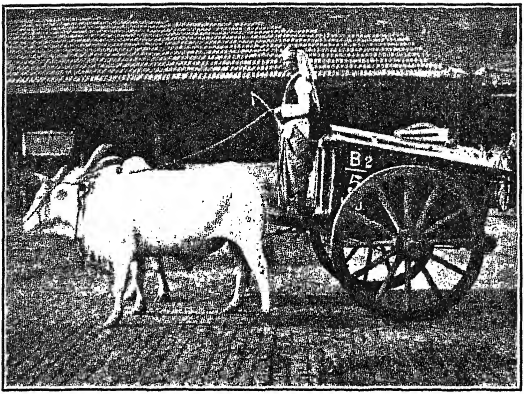
The City has approximately 215 miles of streets with a total square area of 67,34,506 square yards which has to be cleansed twice a day. Of these, 8,53,237 square yards are of asphalt, 126,046 square yards of set-stone pavement, 1,75,853 square yards of tar macadam 16,130 square yards of other

modes of concrete construction, and the rest of the road area is water bound. In addition, 5,494 house gullies or sweepers passages with an aggregate area of 3,29,623 square yards have also to be cleansed both morning and evening.

Street Cleansing is carried out on the "Beat" principle. Each street Scavenger has a definite area of street to cover together with the number of gullies abutting thereon. In one of the wards, the "Beat" principle does not prevail but the "Gang" principle is adopted. Here gangs of 5 or 6 men carry out the cleansing work. Under both systems, sweepings are collected into small heaps at intervals of 20 to 30 feet along the sides of roads and at gully entrances, which collections are picked up by a cart following behind, scavengering women carrying out the work of lifting up the collected heaps in their baskets and emptying them into the carts referred to above and in the absence of the travelling cart into stand-by carts.



SCAVENGING CART AND BARROW.



COVERED CART FOR STREET SWEEPINGS.

The surface of the city streets and roads is being gradually asphalted and the introduction of mechanical sweepers, collectors and road-washers is essential. Sweeping and collection of refuse by mechanical means, means always higher speed resulting in a proportionate increase in the mileage of streets swept. Furthermore the work done would be more effective and economical than that by manual sweeping and collection. These machines would be a real asset to the Health Department.

In order to deal with the daily fouling of the streets with horse-droppings and cow-dung, street Orderlies (boys) with galvanized iron hand receptacles and scrapers are employed. The contents of the receptacles are dumped at convenient spots from which they are subsequently taken to the tips by carts.

Hand barrows are used in some places where large quantities of heavy refuse are collected in small areas and have to be taken to distant stands.

50 orderly bins have been provided on footpaths for light street refuse and paper. They are emptied twice daily by travelling carts.

Notwithstanding the frequency of the sweeping of the streets in the shopping centres, the littering continues. The defect is not in the cleansing work but in the habits of some of the people who thoughtlessly throw down litter or any thing away in the street as soon as it is no longer required. A street freshly cleansed by the staff is often made untidy a few minutes later by careless pedestrians.

Similar conditions obtaining in England are effectively met by the local authorities by the enforcement of Bye-laws. The London and Middlesex County Boroughs have the following Bye-laws :—

"No person shall (1) sweep or otherwise remove from any shop or house into any street any waste paper, shavings, or other refuse or being a coster-monger, news-vendor or other street trader, throw down and leave in any street any waste paper, shavings or other refuse; (2) throw down or leave in any street for the purpose of advertising, any bill, placard, or other substance; (3) willfully or negligently suffer any straw, hay, waste paper, shavings or other litter from any vehicle, packing case, to be strewn about any street to the annoyance of the residents or passengers."

The principal roads and streets in each area are swept 3 to 4 times daily and the very important ones continuously. The less important thoroughfares are attended to twice daily.

In addition to this cleansing, squads of men and women carry out washing of the asphalted roads in various parts of the city or mud and dust collection; the former

operation being more extensive in character during the eight dry months of the year and the latter during the four wet months.

Washing work is a necessity now-a-days and more efficient work could be obtained by the employment of washing machines, the water being applied to the surfaces under pressure. More speedy work is possible without diminishing the effectiveness of the cleansing work and at the same time the results, from the work of these machines would be more economical than those by manual labour.

Gangs of men are employed for flushing out gullies, an operation which continues throughout the year.

A special staff is also employed for the daily cleansing out of all gully-traps in connection with house-drainage and for removing obstructions in the latter, should occasion require it.

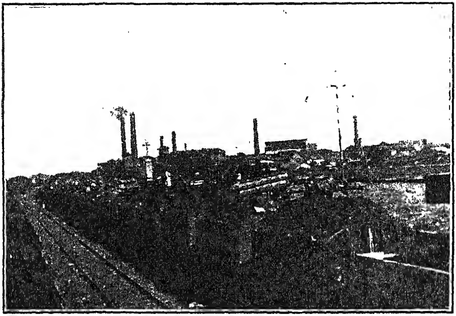
DISPOSAL.

The annual amount of refuse including street sweepings received for disposal through Municipal Agency is 3,79,600 tons, and that delivered by Traders 85,045 tons or a total of 4,64,645 tons.

In so far as the disposal of refuse is concerned the systems at present in operation are three in number, namely, (*a*) by rail to reclamation grounds at Deonar, (*b*) by dumping into the low lying lands in the city (crude tipping), (*c*) by maturing dung in pits into manure.

(*a*) BY RAIL TO DEONAR MARSHY GROUNDS.

The Municipal Rolling stock consists of 173 Railway wagons, of which on an average 60 are brought into daily use for hauling refuse to Deonar.



REFUSE SIDING AT MAHALUXMI.

Two trains each with about 30 wagons run daily, one at 9-30 a.m. and the other at 10 p.m.. A train of 30 empty wagons is kept at Deonar.

The daily amount of refuse transported to Deonar is 780 tons or 284,700 tons per year.

The Deonar estate comprises a total of 823 acres.

The total area reclaimed so far at Deonar with city refuse, approximates 270 acres the depths varying from 6 to 15 feet. this leaves a balance of 553 acres of the estate still to be reclaimed. This reclaimed area is given out to farmers each year for cultivation. The annual income derived from such letting is between Rs. 8,000 and Rs. 10,000.

(*b*) By dumping into low lying parts of the city :—

The low-lying lands owned by the Municipality situated between the Haines Road Hindu Cemetery and the Race Course are available for the purpose. About 500 tons on an average are daily being deposited into this low-lying land or 1,82,500 tons per year.

There is yet another ground rented from the City Improvement Trust at Dharavi which is being reclaimed; about 15 tons are daily deposited here by carts plying in the extreme northern portion of the city or 4,575 tons per year.

The area of land already reclaimed within the city limits in the past admeasures 316 acres which is annually leased for cultivation and the amount realised each year ranges between Rs. 10,000 to 12,000. The land is put up to auction and with facilities for transit fetches these prices.

The land is prepared in May and, on the first appearance of the rains, maize, cucumber and gourd are planted—all in the same field in rows. When these crops are well established in July or August, brinjals and beans are planted amongst them. The maize is collected from the plants and the stalks are beaten down and form a frame for the gourd and cucumber; vegetables and spinach are then planted and this is carried on until March.

English Name.	*Marathi Name.*
Maize or Indian Corn	Kanas.
Cucumber	Kakadi.
Gourd	Shiroli.
Brinjal	Wangi.
Legume	Gowar.
Spinach	Bhaji.

(c) By maturing dung in manure pits :—

The Manure or Dungpits.—All dung from milch cattle stables is being deposited into these pits which are 4 in number. During the months of January to May and October to December in each year, the average daily number of cart-loads of dung dumped into these pits is 32 and in the months of June to September the average is 77.

The annual amount of dung received into the dung-pits on an average is 12,900 cart-loads or 6,500 tons. This makes about 5,900 tons of manure.

The right of selling manure is annually sold out to contractors. The amount realised each year from such sales ranges between Rs. 2,500 and Rs. 3,500.

The Municipality also undertakes the transporting of carcasses of dead animals to Deonar in wagons attached to the

refuse night train which leaves at 10 p.m. Average number of dead animals transported per year is 27,000 (this figure is exclusive of the number of dogs and cats). There is a skinning ground established there. The right of skinning is auctioned annually to contractors and the amount realised each year ranges between Rs. 30,000 and Rs. 50,000.

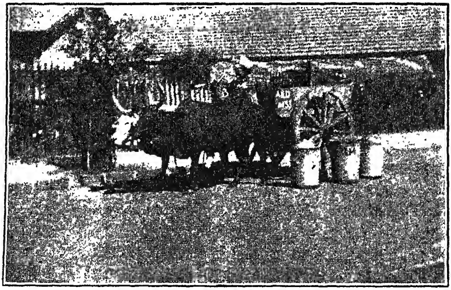
The number of carcasses transported per year averages 3,385 of big animals such as cows, buffaloes, horses, and 23,784 smaller sized animals such as calves, goats, and kids.

The carcasses of dogs, cats and others which the contractor does not skin are thrown to the vultures.

STAFF.

In all 4,684 men, 1,487 women, 50 boys and 434 drivers are employed on the operations in connection with the Cleansing Branch, besides the Superintending and Clerical staffs.

House accommodation for the Labour Staff of the Conservancy Branch consists of 127 blocks with a total of 3,180 rooms. The majority are owned by the Corporation and a few hired. This accommodation houses 6,000 employees, and further proposals are before the Authorities for housing the remaining.



IRON CART AND SANITARY BINS.

The problem of finding an efficient and economical system of disposal of refuse is one of the most difficult ones.

In the western countries many methods are employed each claiming efficiency and economy but the fact remains that the selection of a process can only be made with due regard to the local surroundings. It is only by careful and serious study of local circumstances assisted by scientific analysis of the character of the refuse can one formulate and prepare schemes of refuse disposal suitable to local conditions.

The various processes suggested for refuse disposal may be briefly classed under the following heads :—

(1) Tipping or dumping of refuse in a crude state.
(2) Tipping in accordance with specific regulations.
(3) Tipping or lopping into the sea.
(4) Pulverisation or crushing.
(5) Separation and utilisation.
(6) Incineration.

(1) *Tipping or dumping of refuse in a crude state.*—The tipping or dumping of refuse in a crude state is one to be discouraged. This method has been condemned and rightly so, as being insanitary and unhygienic on the grounds of nuisance from fire, flies and rats. The only advantage this method has is that it is practically always the cheapest.

(2) *Tipping in accordance with specific regulations.*—This form of refuse disposal is being largely adopted in cities where suitable land is obtainable, and without doubt it can be carried out successfully if the recommendations of the Ministry of Health (England) are given effect to. The recommendations are based on the Bradford system of tipping.

The specific Rules to be complied with are as under :—

(1) The deposit to be made in layers, (2) No layer to exceed 6 feet in depth, (3) each layer to be covered on all surfaces exposed to the air with at least 9 inches of earth or other suitable substance except a portion which may be allowed uncovered during the formation of the layer, (4) No layer to be left uncovered for more than 72 hours from the time of deposit, (5) Sufficient screens or other suitable apparatus to be provided where necessary to prevent any paper or other debris from being blown by the wind away from the place of deposit.

In most of the cities of India, the refuse is conveyed to dumping grounds either directly by bullock carts or by rail.

The dumping ground should be well outside the city limits, the refuse discharged on to the ground and covered with a few inches of soil, and planted with suitable crops; maize, sugar-cane and a number of vegetables do well.

(3) *Tipping or lopping into the sea.*—Is a form of disposal only available to few seaside towns suitably situated in close proximity to the sea. This method of disposal is open to serious comment as it may lead to pollution of foreshore as a result of back washes. Furthermore it is a costly method owing to the distance that would have to be travelled out to sea to overcome the possibility of refuse being washed back to the shore.

(4) *Pulverisation or crushing.*—Is a form of disposal whereby different classes of refuse are thoroughly reduced to a fine state to obtain a mixture of organic and inorganic matter which mixture is said to be unattractive to flies and rats. This pulverised stuff is said to possess some fertilising properties and has a value for its physical effects on heavy soils, but the great problem associated with it is to find a suitable outlet for the material after treatment.

Perhaps the greatest setback to the development of pulverisation is the prejudice of the agriculturists. The refuse though reduced to a uniform grade is at the best a very low grade material and the experience in England is that the farmer will not take it. Furthermore, it is stated that the consumption power and wear and tear on the plant are both heavy.

Attention has of late however been directed to the utilisation of such material as a fertiliser or a fuel.

House and town refuse is not now regarded as a waste product to be got rid of but is recognised as an article possessing valuable fertilizing properties when suitably treated.

The treatment consists in passing the refuse through what is known as a lightning crusher or lightning dust manipulator which is a centrifugal-force disintegrator, pulveriser, and mixer combined. The crusher occupies little space, requires relatively small horse-power to drive and works almost noiselessly.

The manipulator consists essentially of a series of steel hammers attached to heavy discs which act as fly wheels and turn at a speed of about 1,000 revolutions per minute. The material to be treated falls through a hopper into the chamber in which the hammers revolve and is at once dashed with great force against a breaking block of special alloy steel, the material receiving about 4,000 strokes from an aggregate weight of over 70 tons per minute, the final disintegration being effected by trituration between the hammers and the grinding plate. When the material is reduced to a proper degree of fineness it drops through a screen on to a chute and thence to a railway waggon when levels permit or is removed by means of a sloping conveyor or an elevator.

Little sorting or picking of the refuse is required. No dust or nuisance of any kind is developed during the process of transformation from refuse to manure.

The transferred refuse occupies only two-thirds of the space of the crude material.

The new fertiliser has been named "humic." In appearance it is like a fine black powder and has a slightly pleasant smell.

(5) *Separation and Utilisation.—(a) Separation.*—This is a post war operation which preserves the incinerative principle for some if not all of this combustible material but not for the innocuous dust, some particles of which are combustible but not profitably so when in a mass. This method of refuse disposal has made considerable headway of recent years and has undoubtedly proved that it is one of the necessary factors in achieving successful and economical disposal of refuse. Plants have recently been installed whereby the refuse after separation has been fed into high temperature furnaces and has proved to be very useful in raising steam. This process of refuse disposal appears from results obtained in various towns and cities within the last few years to be the most economical and efficient one so far introduced. By the separation of some 40 per cent. of dust of an incombustible character a greater steam raising fuel has been obtained in the form of screened refuse. Better clinker has resulted and by-products in the form of tins, scrap-iron, bones, etc., have been salved from the refuse. This has greatly reduced the quantity of refuse to be incinerated and in consequence the cost per ton of disposal of refuse, has been greatly lessened.

(b) *Utilisation.*—This is a very important side of modern cleansing work. For instance the fuel recovered in the form of cinder is the most valuable element in refuse possessing generally a calorific value equal to 75 per cent. that of steam coal. It therefore undoubtedly has good steam-raising qualities and could profitably be applied in municipal undertakings. Markets for other articles recovered are sometimes difficult to obtain and only by concentration, patience, and perseverance can suitable markets be established whether the products be steam, electricity, cinder, fuel, metals, fertilisers,

feeding meals, bones, glass, etc. The chief point is, are they the best products obtainable from the raw material, and at the same time, are they most profitable to the Municipal authorities ?

Household refuse in its massy form may be said to be 100 per cent. obnoxious, but in its separated or segregated condition the nauseative character would be found to be confined to contents 20 to 30 per cent. of the mass only, this depending of course on the season of the year.

(6) *Incineration.—Direct Incineration.*—This method is well-known. It is generally agreed that from the hygienic stand-point it is the most satisfactory, although considerably more costly method as it renders refuse innocuous within the minimum period of collection. Where incineration is the principle employed, the provision of a modern incinerator combined with intelligent method of stoking is the chief essential required for completely sterilising the refuse. The greatest difficulty in connection with incinerators has been brought about by the greatly varying character of the refuse to be destroyed. The method is condemned however, on the ground that it is too costly and there is extravagant waste of good fuel value.

The term " destructor " is applied to a high temperature furnace specially designed for the disposal of town refuse by burning.

Many years of practical experience has led to the design of efficient types of destructors, and has shown what is the true calorific value of average town refuse, so that manufacturers are now able to give definite and reliable guarantees of performance, such as both users and makers may, with a reasonable degree of certainty, expect to realise. The mere disposal of the refuse is not, as a rule, the only consideration kept in view in a modern refuse destructor station. A complete installation for a population of, say 50,000 persons may cost from £5,000 to £6,000 to erect, according to local circumstances, and, in addition to the destructor cells proper,

usually includes machinery and plant for the removal and disposal of the residual clinker, for its crushing and manufacture into paving slabs, bricks, mortar, or other saleable products, also steam and engine power for actuating the various plants required at such a station. It will, therefore, be evident that the working expenses, maintenance, and depreciation of a fully equipped installation must necessarily be considerable, and that, with the view of reducing this annual expense to a minimum, it becomes necessary to turn to account any and every by-product or residual material which can be really diverted to profitable use.

POINTS TO BE ENQUIRED INTO WITH REFERENCE TO REFUSE DESTRUCTORS.

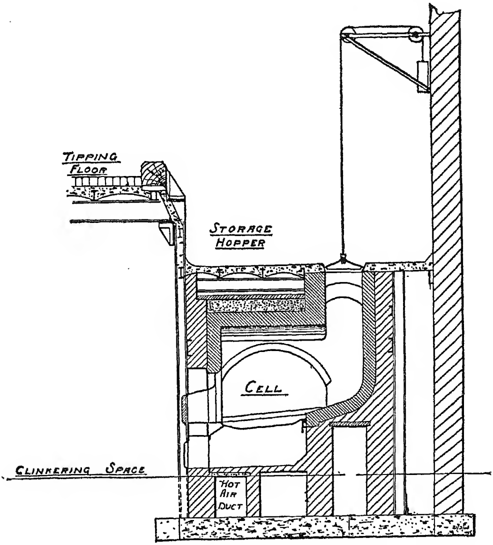
(SUGGESTED BY F. WOOD.)

1. The grate area and the amount of refuse burnt per square foot of grate area.
2. Do the fumes of the burning refuse pass over bright heat to ensure their perfect combustion ?
3. The lowest temperature in the furnace, or in the combustion chamber, should be 1,300° F.
4. The temperature at the chimney flue, and at the combustion chamber.
5. The analysis of the gases at the flue should be procured. There should be less than 1%of CO. The amount of free O and N should approximate the amounts found in the atmosphere near the flues. CO_2 should be abundant. 6% being frequently got ; as much as 15% has been obtained.
6. The amount of water evaporated at 212° F. per pound of refuse per hour.
7. The cost of labour per ton of refuse delivered.
8. Cost of maintenance, together with the number of men required to work.
9. Is skilled labour necessary ?
10. What method is employed to feed the destructor ?
11. The construction of the destructor. Is an inclined road-way necessary ? Height of chimney.
12. Disposal of clinker, and revenue derived from its sale.
13. The number of cells required for every 10,000 inhabitants.

In large towns the destructor will be found to be the best method of disposal.

Destructors are so constructed that the nuisance is reduced to a minimum, and so much so that in large towns in England they are in some instances placed close to dwelling houses, schools, &c.

CROSS SECTION OF THE CELL OF DESTRUCTOR.



CROSS SECTION THROUGH CELL

The best known destructors are :—

Horsefall.	Heenan and Froude.
Meldrum.	Baker.

One or more large furnaces are used. The refuse is thrown in at the top, and becomes dry as it sinks down, all organic matter is burnt off and at intervals the mineral matter, or "clinker," is raked out below, to be used for road making, filling up hollows, &c. After the furnace is started, the organic matter in the refuse is usually sufficient to maintain the fire without the addition of other fuel. The smoke from a destructor is offensive and should be passed, through a second furnace. At Bradford the smoke is rendered inoffensive by forcing a jet of steam, under pressure, beneath the fire bars (Horsefall's Process), and secondly by passing the fumes through a Jones's "Fume Cremator," which consists of a coke furnace provided with several projections or "bafflers."

There are various *types of refuse destructors*, most of which possess the following features in common :—

(1) Furnaces or cells of brick with fire brick lining. (2) Approaches by an inclined roadway to the top or tipping platform. (3) In the centre of this platform is a series of feeding holes or hoppers into which the refuse is shot to fall into the cells below. (4) The stokers rake the refuse on to the fire, and after burning, the refuse is reduced to about $\frac{1}{3}$ or $\frac{1}{4}$ of its original weight, the residue consisting of fine ash, hard clinker, &c. (5) By means of forced draught produced by a steam jet or fans, the combustion can be made so complete that temperatures of 1,500° to 2,000° F. are attainable merely from the burning of the refuse.

Some destructors are known as *slow combustion* or *low temperature destructors* and in these "fume cremators" should be provided at the foot of the chimney. In the *high temperature* destructors, such cremators are unnecessary.

Low Pressure Destructors.—Advantages.—a diminished wear and tear and hence saving in upkeep. *Disadvantage :—*

the inlet for refuse and the outlet for gases are at the rear of the cell and hence noxious vapours escape before being burnt and a cremator is necessary; also more cells are required.

High Temperature Destructors.—(Horsefall) the outlet for gases is at the front of the cell and the vapours given off pass over the hottest part of the fire to reach the exit; the foul gases are destroyed within the cell itself; a large quantity of refuse is burnt per day per cell (10 to 16 tons) and fewer cells are therefore required. These cost more for maintenance. The number of cells depend on the nature and amount of refuse to be destroyed and also upon the type of the cell adopted. If a *high Temperature Destructor,* 10 cells will be required for a population of 100,000. These cells can be erected in a single row or back to back.

THE HORSEFALL DESTRUCTOR.

The following is a description of the Horsefall Destructor:—

The buildings are laid out in four bays, the destructor furnaces occupying the bay nearest the entrance. This bay is 110 feet long, by 40 feet wide, by 41 feet high. The two centre bays accommodate two sets of boilers for destructors and coal firing respectively, while the last bay (the largest of the four) is the electric power station.

A pump-room, which serves both sets of boilers, adjoins the power station; and the economisers, of which there are two, are housed outside the main building.

The chimney, 150 feet in height by 10 feet internal diameter, is situated at the end of the boiler-house.

A concrete retaining wall and water reservoir are built at the south end of the site, and water is conveyed by an 18-in. pipe from the reservoir into the power station for condensing purposes.

DETAILS OF THE DESTRUCTOR.

The Horsefall Destructor consists of six large cells and combustion chambers, with three water tube boilers, arranged

so that each pair of cells with its boiler can be worked independently. This arrangement of independent "units" permits of any section of the plant being shut down for repairs or cleaning, without interfering with the working of any other unit.

By firing the two cells of each unit alternately, a steady steam pressure is maintained in the boiler, while the combustion chamber is also kept at a sufficiently high temperature to cremate thoroughly the noxious gases which escape from the newly-charged refuse.

The furnace grates, which slope from back to front, have each an area of 25 square feet and are constructed to burn efficiently a full cart-load of refuse at one charge. The grate bars are perforated with a large number of small holes and a high pressure blast is forced through these, by means of electrically driven fans.

It is generally recognised that to ensure complete combustion in destructor furnaces, an air-blast system is the best, but hitherto the blast has been delivered at comparatively low pressure.

The grates and fans are constructed for a specially high pressure, and are fully expected to show a distinct gain in efficiency over the older system.

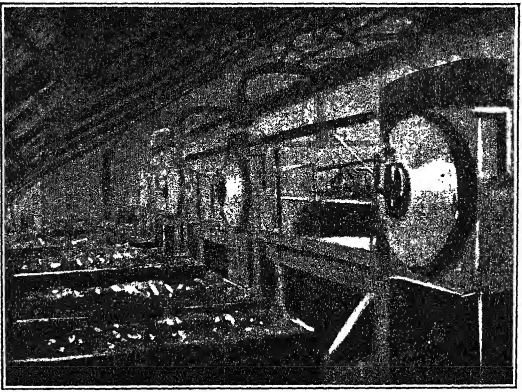
The fans, of which there is one to each furnace, are coupled direct to "Phœnix" variable-speed motors of the totally enclosed type. The starting and regulating switches are fixed conveniently to the furnace doors, and a throw-off switch is actuated in such a way that the opening of the door automatically stops the fan. Incidentally an attempt has been made to improve the unfavourable atmospheric conditions existing in most destructor installations, and ventilation is provided for by carrying the fan inlets to the underside of the storage platform and turning them inwards so that all dust and fumes emitted during the process of "clinkering" are drawn in and delivered back to the fires.

Auxiliary steam jet fittings for steam blast have also been provided, but these are only intended to be used in the event of a breakdown of the fans.

THE SYSTEM OF CHARGING.

The method of storing and charging the refuse into the cells has been specially designed to reduce manual labour to the lowest possible minimum and forms a striking comparison to some types of destructor still in use, in which the refuse is stored in loose heaps and fed into the furnaces by hand labour.

The refuse is delivered from the carts to the furnaces without handling of any kind, and, while effecting a saving in the cost of labour, ensures a degree of cleanliness which is remarkable, having regard to the nature of the materials dealt with.



TUBE CHARGED READY FOR INCINERATION.

The tipping pit is situated at the north end of the destructor house, and the refuse, which is delivered by carts,

is discharged through a specially shaped hopper into a storage tub placed ready in the pit.

The pit has accommodation for four tubs, with two hoppers, the latter being arranged to move on rails across the pit.

When the tub has been loaded, the hopper is moved clear from above it, and an electrically operated over-head crane lifts the tub and deposits it on the storage platform, where it is kept till required. The storage platform extends to the full length of the furnace blocks, and has accommodation for eighty tubs.

The storage of refuse thus takes place in closed boxes away from the heat of the destructor.

CHARGING GEAR.

When ready to charge, a tub-full of refuse is lifted from the storage platform by a crane, and placed on a moveable cradle on the top of a cell. The weight of the tub causes the cradle to descend, and by a system of levers and balance weights, the water-sealed door is lifted from its seat and drawn on rails to one side, permitting the lower edge of the moveable cradle to descend into the mouth of the charging doorway. The storage tub is provided with hinged lids at the bottom which are held shut when the tub is suspended by the crane, but when released these lids open outwards and the whole of the refuse thus falls, directly into the furnace and spreads itself over the grate.

The empty tub is then lifted by the crane, and the water-sealed door, actuated by the balance-weight, is mechanically drawn back to its seat. The whole operation of charging the cell and withdrawing the tub occupies less than a minute, and as the furnace door is open for only a few seconds, the inrush of cold air, with consequent reduction of furnace temperature, is reduced to the smallest possible amount.

The crane, which has a lifting capacity of 3 tons at 30 feet per minute, was built by Messrs. Broadbent & Sons, Huddersfield.

The time required to cremate a charge thoroughly varies according to the class of refuse, from one to one and a half hours, and the fire is then cleansed through a large clinkering door at the front of the cell. This door is of specially strong construction, and is provided with two small doors attached to it, so that the fire can be adjusted and managed without opening the main door.

The clinker is withdrawn from the furnace into buckets suspended from an over-head clinker railway, and may either be delivered directly to the clinker crushing and screening mill or deposited in heaps until required.

BOILERS.

A main flue of large area is provided for each pair of cells, from which the hot gases are carried through the combustion chamber of water-tube boilers, and a dust catcher of Messrs. Horsefall's patent type is built in between the combustion chamber and the boilers. All the flues are lined throughout with fire-brick, and in the furnaces specially made fire-clay blocks, set in fire-clay cement, have been employed.

The boilers are of Messrs. Babcock & Wilcox's marine water-tube type, constructed for a working pressure of 200 lbs. per square inch, and fitted with super-heaters to raise the temperature of the steam to 500 deg. Fahr.

To meet any special demand for steam, auxiliary grates have been fitted for coal firing, and a bye-pass is provided direct from the destructor combustion chamber to the main over-head flue, so that in the event of a breakdown of a boiler or an excess of steam being generated, the whole or a portion of the hot gases may be taken by this route instead of through the boilers.

After leaving the boilers, the gases pass by way of the over-head main flue to an economiser, thence to the chimney.

The economiser is of Messrs. Green's type, built into two sections of 120 tubes each.

The steam from each boiler is led from the super-heater to a 10-inch main, and carried direct to the main range which supplies the electric generators. The feed piping is connected

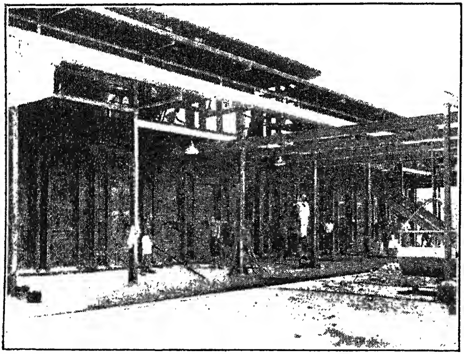
by a branch pipe to the system supplying the coal-fired boilers, the arrangement being designed so that the destructor boilers can be fed either through their own economiser or from the hot-feed main of the coal-fired boilers.

The pump house contains two triple-throw electrically driven Worthington pumps, and one of Messrs. Weir's double acting steam pumps. A storage tank of 12,000 gallons capacity is placed over the pump room, and a combined water-softening and de-oiling plant is provided to treat the feed-water.

The coal-fire boilers are of Messrs. Babcock & Wilcox's double-drum type, each boiler being capable of evaporating 18,000 lbs. of water per hour. Super-heaters are provided, and the firm's latest type of chain-grate stoker is fitted.

GENERATING PLANT.

Passing into the engine room, a lofty, well-lighted building, there are two Bellis-Westinghouse direct-coupled generating sets, each capable of a normal output of 750 kilo-watts when supplied with steam at 200 lbs. pressure.



VIEW OF FURNACES.

The engines are of the triple-expansion, quick-revolution, enclosed type of 1,140 horse power each, and are fitted with expansion valves to take over-loads up to 50 per cent.

The exhaust steam is taken through an oil separator into a surface condenser, which serves both sets of engines.

A special feature of the works is the use of the electrically driven auxiliaries, and the whole of the auxiliary plant, including pumps, stokers and fans, is driven by electric motors.

The following observations as to the general methods of working the Fryer Destructor apply also, with slight modifications to meet special circumstances, to all hand-fed destructors:

"The cart, on entering the yard in which the destructor is built, is drawn by a horse up an inclined roadway with varying gradients, from 1 in 12 to 1 in 25, and on arriving at the top a platform is provided with tipping curbs, against which the carts are backed and their contents are tipped on to the top of the cells. Here the material remains for a short time, until one of the cells is ready for a charge, the charging holes being in direct communication with the fire, but so arranged that very little smoke at any time issues from them. When a cell requires to be charged the material is shovelled or drawn with a two-pronged rake into and on to the top of the charging hole. A second man stands in line with the opening and as the material is delivered on to it he pushes it down the incline on to the drying hearth and continues doing so until the hearth is completely covered. The quantity usually put on at one charge varies from one-third to one-half a cart load, or from 20 cubic feet to 30 cubic feet. From the drying hearth the material is drawn down on the bars as required by the fireman, who stands at a lower level and in front of the furnace. He first clears his fire by pulling the clinker out, spreads the burning material evenly over the fire bars, and then draws down a fresh supply of the partially dried material from the drying hearth. He usually finishes up by running his bar through the fire, so as to leave as free a passage for the air as possible.

"Too much refuse should not be drawn down at once, or the fire will become dead and blackened. Thin layers may be raked down at intervals of about 20 minutes, but the fires should be undisturbed for at least half an hour before a clinkering. The fire on the bars (which should always be kept covered) should not be more than about 9 inches thick, which is sufficient to secure a clear fire.

"The clinker falls into a barrow provided for the purpose or upon the ground in front of the furnace, where it is cooled by having water from a hose sprinkled upon it. The fine ash drops through the bars into the dust hearth, and it is found that the material in passing through the furnace is reduced to about 25 per cent. of its weight. This residue consists partly of fine ash and partly of clinker, in varying proportions according to the character of the material which has been consumed. Whilst the combustion is proceeding, the hot gases from the furnace or cells escape over the bridge into a central flue 6 feet high by 10 feet 4 inches wide. This is arranged to prevent too great a velocity from carrying pieces of paper and other unconsumed material to the chimney, and also to allow of the deposit of dust within the flue."

THE MELDRUM FURNACE.

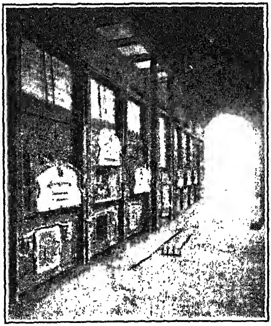
The Meldrum patent "Simplex" Destructor is a modern apparatus manufactured by Messrs. Meldrum Bros. of Manchester. In this furnace, it is claimed, ordinary town refuse will give a sufficiently high temperature to utterly decompose all noxious material, nothing but harmless and inoffensive gases passing up the chimney, the solid residue consisting entirely of hard clinker with a little ash. When it is desired to utilize all the available heat for steam-raising, a special internally fired steam generator is employed.

Ordinarily, the furnaces are fed by hand, but hopper feeding may be arranged if required. A forced draught is used in connection with the furnace, but no cremator is considered necessary, owing to the high temperature of the cells.

It will be observed that four grates are placed side by side and separated only by dead plates, the ashpit, however,

being divided in four parts, each separately fed with a supply of air under pressure, preferably by steam air blast. The destructor, therefore, is practically a single cell, fed and cleaned in four places at regular intervals, so that an approximately constant temperature may be anticipated.

The escaping gases either pass away from the back of each fire grate into a common flue leading to boilers or the chimney, or are conveyed sideways over the various grates, and thence over a common fire-bridge towards the boilers or chimney. After passing the fire-bridge, it will be seen, there are five rows of baffle pillars arranged to divide and break up the current of hot gases; the pillars remain constantly at a bright red or white heat, and take the place, it is claimed, of the cremator furnace commonly used in the older destructor installations. A bye-pass is, of course, provided in order that the furnaces may be used without the boilers. The patentees recommend that four grates be laid down, but fewer or more may be provided to suit circumstances. One or more of the grates may be disused without interfering with the working of the remaining portion of the destructor.



MELDRUM FURNACES AS INSTALLED AT CROYDON.

In regard to the question of the number of "Meldrum" cells required proportionately to any given population, if we take the annual production of house refuse per 1,000 inhabitants at 200 tons, then a single "cell," that is, a grate 5 feet by 18 feet, having four ashpits, and burning at an assumed average rate of 40 lb. per square foot per hour, would consume about 38 tons per day of 24 hours or per year of 300 days—say, 10,000 tons. Consequently, if this rate of consumption be uniform and constant throughout the year such a cell or destructor should suffice for 50,000 people. The heat derived in indicated horse-power per cell would theoretically—assuming a maximum of 2 lb. of water evaporated per lb. of refuse consumed—be equal to

$$\frac{90 \text{ sq. ft.} \times 40 \text{ lb.} \times 2}{20} = 360 \text{ horse-power continuously per cell}$$

at 20 lb. steam per 1 horse-power per hour.

A height of chimney shaft of 40 ft. is said to be ample for the requirements of the "Meldrum" furnace; and the temperature in the cell, if fitted with a regenerator, may be taken as averaging about 2,000 deg. Fah.

GENERAL SCHEME OF THE NEW PLANT AS INSTALLED AT HULL, BY MESSRS. HEENAN & FROUDE, LTD.

"On arrival at the Depot all refuse passes over a weighbridge where the weight and classification of each load are recorded by the attendant, and the vehicles pass thence by way of the inclined roadway, to the high level tipping beam at the main refuse reception hopper of the mechanical handling plant, or direct to the emergency tipping beam in the rear of the top feeding floor over the furnaces.

Emergency tipping is provided to ensure continuous operation of the furnaces in the event of mechanical breakdown in the handling plant and also to admit of market and other special refuse which does not require screening, and magnetic treatment for separation of tins, etc., to be tipped direct on to the top feeding floor.

The normal flow of refuse is, however, by way of the mechanical handling plant, commencing at the main reception hopper which has a storage capacity of 45 cubic yards. Here the vehicles are tipped over a beam as they arrive, the refuse being gradually and evenly fed out of the hopper by means of a slowly moving plate conveyor, 7 ft. wide, which forms the hopper bottom.

$\frac{3}{8}$ in. and $1\frac{1}{2}$ in. Screens.

The discharge from the conveyor is on to a totally enclosed elevator 2 feet 6 ins. wide, which in turn discharges into a 7 feet, 6 ins. dia. circular horizontal screen, where both dust—$\frac{3}{8}$ in. mesh—and cinders—$1\frac{1}{2}$ in. mesh are taken out, the former being sorted in an overhead hopper of 30 tons capacity for discharge to and removal by road vehicles, and the latter taken away by a belt conveyor to the cinder cleansing plant, which is described later. By means of a deflecting shoot the screened cinder can be delivered when desired on to the tailings conveyor for incineration in the furnaces.

The outlet end of the circular screen is provided with a powerful electro-magnetic separator of the horse-shoe type, which recovers tins and other magnetic materials from the refuse tailings as they pass out of the screen barrel. The tins. etc., are delivered by means of a shoot to the room beneath where a mechanical motor-driven super-bailing press is provided. This machine has a capacity of about 10 bails per hour, each measuring 18 ins. by 12 ins. and weighing approximately 60 lbs.

After leaving the screen the tailings are received on a belt conveyor, 36 ins. wide, travelling at a speed of 45 feet per minute, from which is picked by hand, rags, paper, bottles, and other salvable articles which have a market value, these being collected in baskets and stored in bins

until disposed of. The salved paper is deposited in bins along side the conveyor and is discharged to a mechanical motor-driven paper press in the room beneath, where the tin baling press is also fixed.

The paper press has a capacity of about 6 bales per hour, each measuring 3 ft. by 2 ft. by 2 ft.

The delivery end of the tailings conveyor is elevated and fitted with a rotating discharge shoot to ensure a wide distribution on the top feeding floor of the tailings delivered there for incineration in the furnaces.

Incinerator Plant.

The destructor consists of one unit of 5 cells or furnaces on the "Heenan" system, each cell having its own independent ashpit with controlled air supply.

The grates are of the flat type, each 30 square feet area and continuous, giving a total grate area of 150 square feet.

Refuse is handfed into the cells by means of circular openings in the main arch and firebrick lined doors in the top feeding floor, each cell having its separate feeding door.

The cells are hand clinkered at the front through large door openings, the clinker being disposed of to the storage yard by means of steel skips suspended from hand propelled travelling runaway blocks on an overhead runaway track.

A large combustion chamber is provided at one end of the battery of the cells where the gases are thoroughly mixed and burnt before passing to the boilers. The combustion chamber is provided with specially large doors which will admit the insertion of a whole carcass or other bulky articles for cremation.

Two "Babcock & Wilcox" patent water tube boilers are provided in one setting, each having a heating surface of 2,422 square feet and capable of raising together 18,000 lbs. of steam at a working pressure of 200 lbs. per square inch. Super-heaters are fitted integral with the boilers and are capable of raising by 100° F., the whole of the steam produced by the boilers.

The two boilers are so arranged with their respective flues and controlling dampers that either may be fired independently of the other, or they may be worked together. The two auxiliary furnaces are also quite independent of each other.

Each boiler is also fitted with a complete installation of calorized Diamond soot blowers which are permanently fixed in the setting.

Auxiliary Furnaces.

Auxiliary Furnaces of the Turbine type are built at the front of each boiler for the purpose of maintaining steam throughout the night after the available supply of refuse tailings has been consumed. Fuel for the auxiliary grates is provided by the cleaned cinders recovered by the main circular screen and the cinder cleaning plant.

Forced draught for the destructor cells is supplied by a motor-driven centrifugal fan which delivers air to the closed ashpits at a pressure of 3 in. W.G.

Feed water is supplied to the boilers by a "Weir" vertical type steam driven pump and an injector is provided for emergency and stand by. The boiler feed is passed through vertical heaters which are supplied with exhaust steam from the generating sets and feed pump. Two heaters are provided, each having a heating surface of 35 square feet, and the arrangement of piping and valves is such that either, or both heaters may be cut out of service. In the latter case the generating sets and pump would exhaust to atmosphere.

GENERATING PLANT.

The Generating Plant consists of two steam driven shunt-wound generators of 75 K.W. capacity, each running at a speed of 600 r.p.m., and supplying a direct current at a pressure of 230 volts. The generators are direct-coupled to steam engines of the enclosed forced lubrication vertical double acting type, taking superheated steam direct from the boilers and exhausting, as above described, to feed water heaters or direct to atmosphere. The current generated is used for the various motors which drive the new plant, and for lighting the depot.

The switchboard consists of polished ebony Sindanyo panels and comprises two 75 K.W. generator panels, two power feeder panels and one lighting panel, each feeder panel having two 150 amp. circuits and the lighting panel one 60 amp. circuit.

All power wiring between the switchboard and the various motors about the works is carried out with V.I.R. cables in enamelled and screwed conduit.

A constant supply of superheated steam from the boiler goes direct to the adjacent works after being reduced to 140 lbs. pressure, and a "Kent" recording steam flow meter is installed in the engine room for this service.

Other meters and instruments installed comprise a "Helix" water meter in the boiler feed service, and a steam pressure recorder in the common steam main, connecting the two boilers.

A water softening plant is provided in which all feed water for the boilers is subjected to a lime-soda process for reducing the hardness. This plant has a capacity of 2,000 gallons of water per hour and the water is stored after treatment in a separate tank of 2,000 gallons capacity. A settling tank is also provided to enable sludge from the treatment plant to be recovered before the drainage water is turned into the main drainage system of the work.

CINDER SEPARATING PLANT.

The Cinder separating plant, which receives all the cinders screened out of the crude refuse by the main screen, consists of a "Heenan" patent separating device which gives a clean cinder product with only a small percentage content of foreign matter, thus providing an excellent and cheap fuel for steaming the boilers when refuse is not available. A storage hopper of about 18 tons capacity is provided, into which the cleansed cinders are delivered by a bucket elevator and from which they can be drawn at will to vehicles for delivery to the boilers or as may be required.

Debris from the Separating Plant is disposed of to the destructor, or by vehicles to outside the plant. A storage hopper of about 16 tons capacity is provided to receive unseparated cinders delivered by belt conveyor from the refuse screens.

CLINKER TREATMENT.

Clinker is recovered from the cooling and storage yards by means of side tipping wagons on portable narrow-gauge track, and delivered at the crusher platform of the clinker grading plant. The Crusher is of the two roll type, each roll being independently belt-driven, and the shells made with axial corrugations. One of the rolls is adjustable to vary the size of the crushed product, and is retained by powerful coil springs, which allow foreign materials to pass through without injury to the rolls. The crushed clinker is elevated to a circular screen above a set of overhead storage hoppers of about 40 tons capacity, which are sub-divided for the storage of three grades of clinkers, which can be loaded direct to road vehicles.

An 8 ft. motor mill of the underdriven type with rotating pan has been installed in the old destructor building for making clinker mortar, the crushed clinker necessary for this purpose being obtained from the approximate division of the clinker grading plant storage hopper.

All sections of the plant are driven by electric motors of the enclosed ventilated type, with control gear fixed on the building wall adjacent, and the cables are so arranged that different sections of the work can be isolated from the main switchboard.

The buildings, housing the mechanical plants, are of steel frame construction covered with asbestos cement corrugated sheeting on roofs and sides and lighted by means of glazed steel sashes. The new destructor building is of brick construction with slated roof and the generator house is adapted from a building previously used as an isolation stable.

CAPACITY.

The complete mechanical and destructor plant is capable of dealing with 120 tons of domestic and trade-refuse per day, the former in one shift of 8 hours and the latter in two shifts of 8 hours each.

DESCRIPTION OF SPECIAL FEATURES.

The special features in the Heenan system may be tabulated as follows, but not necessarily in the order of their importance:—

- (a) Continuous furnace chamber with divided ashpits.
- (b) Special air heater or regenerator.
- (c) A rational and effective ventilation system.
- (d) Simple mechanical means for handling refuse and clinker.
- (e) Instantaneous charging.
- (f) A simple mechanical clinkering device applied to each of the main grates.
- (g) Elimination of all dust.
- (h) A special furnace design which assures good results both in the dry and in the monsoon periods.
- (i) Labour saving appliances.
- (j) Control of the chimney draft.

DESCRIPTION OF THE SMALL INCINERATORS IN USE IN MADRAS.

Dr. W. R. MacDonald, late Health Officer of Madras, thus describes the method of small incinerators in Madras :—

"These were designed and modified to suit local conditions by Mr. C. L. T. Griffith, A.M.I.C.E., (now Professor of Engineering College), while Engineer to the Corporation of Madras. It may be mentioned that his experiments were conducted under monsoon conditions in the latter part of 1910. The structure is a brick masonry one, with three rows of iron bars superimposed and each row placed at right angles to the other ; in the bottom of the furnace, ample draught apertures are allowed for, below and above is an upright masonry chimney on which is usually placed a 12′—16′ iron chimney ; an iron lid with a baffle plate is placed over the furnace, which is opened and closed by means of a wire pulley attached high up on one side of the masonry chimney. The cost of erection is a recommendation also, as the masonry work costs only Rs. 100 and the iron chimney Rs. 25 only.

SEPARATION OF COMBUSTIBLE FROM INCOMBUSTIBLE RUBBISH.

"(1) By drivers and sweepers in the divisions. In the forenoon trips a rough separation is made, so that nearly all combustible material reaches the incinerator in the forenoon. What is left behind for the afternoon trips is nearly ashes and earth sweepings which contain a small quantity of organic matter. This is not usually taken to the incinerator but to the 'screeners' near by, where combustible material is separated out and carried a short distance to the incinerator.

"(2) By hand, rakes and forks, which is the first operation on the arrival of the carts at the incinerators in the forenoon ; women and boys do the light work of picking out brickbats broken earthenware utensils, tins and other incombustibles.

"(3) By screening: after the bulky burning material is separated out from these incombustible materials, a residue of earth, mixed with vegetable matter, smaller pieces of bricks, bottles, etc., is left. This is then conveyed to the 'screeners' for finer separation with the result that we have, when screening operations are complete, a finely powdered earth with a small quantity of organic matter. Night-soil has always been carefully excluded.

"The 'screeners' are double, a large mesh in front, a smaller mesh behind, so that we get double 'screening' with the same operation. The wire work of the 'screener' is of expanded metal, the large mesh being $1\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{1}{8}''$ whilst the smaller is $\frac{1}{4}'' \times \frac{1}{4}'' \times \frac{1}{8}''$. The frame work is of wood on which the expanded metal is fixed by bolts. The 'screener' is placed in an upright sloping position and is supported by two supporting wooden legs hinged to the upper part of the wood work frame.

"One is constrained to believe that these small incinerators for the disposal of rubbish in Madras City have proved a sanitary and financial success, and that there is an important place for them in connection with conservancy in mofussil towns and villages in India and Burma, where the rainfall is not excessive.

"I. *Incineration of night-soil mixed with rubbish.*—Experiments were conducted for the disposal of night-soil along with rubbish at Chetput by means of one of these small incinerators, for about one month.

"Night-soil was procured from the two sanded latrines in the paracheries near by. It was free of liquid, but slightly mixed with sand. About 15 cart loads of suburban rubbish were brought in daily. After separation and screening, night-soil was freely mixed with the rubbish and then transferred to the incinerator furnace. So far as the disposal of the night-soil was concerned, the results were eminently satis-

factory, as the night-soil of 400 persons (half the population of the paracheri) could be disposed of daily without difficulty. The gases given off from the incinerating night-soil, however, proved such a vile nuisance, that I was compelled to discontinue these experiments. I am of opinion, however, that by using a *dome* incinerator this nuisance can be effectively controlled.

" II. *Incineration during the monsoon.*—It will be seen on reference to the meteorological table that most of the rain for the year in Madras City falls during the months of September, October, November and December. When rain falls continuously for a day or longer, conservancy operations are entirely suspended so far as the removal of rubbish is concerned; but when rain falls during some part of the day or night, incineration operations are retarded on account of the sodden condition of the rubbish brought in. To combat this condition various measures have to be adopted. The rubbish is separated in the usual way, and spread out to dry in the open when sunshine is available. or under a *kutcha* shed. One's experience in Madras has been that rubbish spread out for a short time in the sunshine and then sprinkled with crude kerosene oil can be disposed of by these small incinerators. Screening operations, however, have to be suspended temporarily until most of the moisture has been removed."

NOTE ON COLOMBO REFUSE DESTRUCTOR.

BY C. L. COX, ESQ.,

City Sanitation Engineer, Colombo.

House rubbish in Colombo is collected in portable sanitary rubbish bins, the use of which is enforced throughout the City, and, together with street refuse, is removed in specially designed self-clearing single-bullock carts.

2. Owing to difficulty in obtaining suitable sites, trouble in securing an efficient transport service and the sanitary objections against refuse dumping in the vicinity of the City, the Municipal Council have established a Refuse Destructor.

3. The following description of the plant and its method of operation is derived from particulars kindly supplied by the Works Engineer.

The plant is of the Horsefall Back Feed continuous grate type with six cells designed to dispose of 10 tons each per 24 hours. The hot air blast to the furnaces is supplied by two Roots blowers drawing air through regenerative air heater from the intake over the rubbish delivery hoppers. The plant includes a Babcock & Wilcox boiler, an auxiliary oil engine for the blowers, two beast cremating chambers and a dust catcher of the Accrington Patent type.

A feature of the plant is the additional oil fuel heating apparatus for use with wet rubbish. The oil atomized by super-heated steam and mixed with air, is ejected into the furnaces through spraying nozzles.

The refuse delivery hopper has a storage capacity of 30 tons. The back is sloped to deliver the refuse to the feeding floors, and the openings through which the refuse is tipped are closed with balanced doors.

The plant has been in satisfactory operation for nearly a year, and the following notes may be of interest.

The rubbish contains a large proportion of sand and mineral matter. In wet weather it is 25 per cent. heavier than in dry. The capacity of the plant varies from 45 tons per diem in wet weather to 75 tons per diem in dry.

The cost of destruction, including all charges except amortization and the cost of liquid fuel for the auxiliary burners, varies between Rs. 1-30 cents. and Rs. 1-50 cents. per ton. A saving of 16 per cent. in rubbish transport charges has been effected by the use of the destructor. The furnace residue which consists of broken bricks, tiles, sand, fine ash and friable clinker, amounts to about 40 per cent. by weight of the rubbish burnt. Except as filling the furnace, residue would appear to be useless, but the fine ashes are being tried on cocoanut estates and the dust from the flues

and combustion chamber is stated to possess some value as a fertilizer for use on local paddy fields.

In the initial stages some trouble was caused by the accumulation of fine dust in the flues and regenerator, but this has been obviated by providing additional access and clearing openings.

The oil jets are not entirely satisfactory and the benefit derived from their use does not correspond with the heavy expenditure of fuel. The defect is attributed to the fact that the flames do not properly impinge upon the rubbish."

SUMMARY OF THE PRACTICAL APPLICATION OF THE FOREGOING BY THE SANITARY OFFICIAL IN INDIA.

In tropical and sub-tropical climates, the necessity for the early removal of refuse is increased by reason of the higher temperature, especially in moist atmosphere, accelerating decomposition.

Flies and vermin multiply more rapidly, and bacteria, harmless and otherwise, propagate in suitable surroundings. The necessity of immediate removal of refuse and cleansing of premises is obvious. The conditions of life and the habits of the people are in themselves important factors which have to be considered.

A large proportion of the inhabitants of India have no conception of the value of sanitation, and the Sanitary Officer becomes as much a teacher as an executive officer, and this is an important part of his duty if he desires success.

It is a common thing to see a room occupied by the poorest, full of shining brass pots, but how are these pots cleaned ?

Road scrapings and dirty water, cow dung and silt form the material of cleansing. The milkman or *Gowli* cleans his milking pots in the same way; any moist earth, cow dung or sand available is used, and mixed with water from a dirty stream, foul well, or wherever it can be had.

At the bathing places where hundreds congregate, round a well or tank or stream, the clothes and mouth and teeth are all washed in the same water, while others can be seen cleansing their pots and cooking utensils and milk vessels with the dirty water and road scrapings surrounding the bathing place.

The practice of expectorating anywhere, and at any time is so frequent as to be noticed by anybody, while a man will clean his nose with his hand, and wipe his hand on the nearest projection, lamp post, wall, a passing cart or his clothes.

Public latrines and urinals are provided, but are more often misused than not, while every corner or house-gully is used as a urinal even if accommodation is only a few feet away.

Every form of filth is thrown out of the window on to the street, and packets of paper or leaves containing excreta may constantly be seen descending on to the pavement or street, very often on the head of a passer-by.

In the most crowded thoroughfares of large cities, it is a common thing to see people performing their ablutions on the pavement, or sitting at their shop doors, washing themselves, and the waste water running across the footpath.

Every form of waste material is thrown on to the streets, the idea being that the Municipal sweeper will pick it up.

In many of the houses of the poor are to be seen goats and fowls, sometimes cows and calves, living in the same room, the animals living on the refuse in the streets and shops.

In towns where sanitary laws and bye-laws exist, some attempt can be made to improve these conditions by constant inspection, supervision, action and instruction.

The following notices are issued in Bombay and action is taken against the offender :—

NOTICE.

WASTE PAPER FROM OFFICES AND TRADE REFUSE.

A great nuisance is caused by the Hamals of shops and offices depositing all the waste paper, wrappings, cardboards, sweepings, &c., &c., in the wire cages on the footpath. These cages are simply meant to be orderly boxes to hold small quantities of paper and dry materials picked off the passages and streets pending the arrival of the conservancy carts.

The proper place for the deposit of the waste paper and sweepings from your office is the dust-bin cart or the travelling cart which calls 3 times a day between 6 a.m. and 9 a.m., 9-30 a.m. and 10-30 a.m., and 2 p.m. and 4 p.m. I must therefore request you to instruct your sweepers not to deposit office waste paper or dust sweepings in the wire cages but to either send it to the nearest dust-bin stand or place it in the travelling cart which passes your door thrice daily. If you will provide a sack the waste paper can be easily removed without nuisance if you will make an arrangement with this office. Trade refuse is not removed by the Municipality free of charge but must be taken at the producer's expense to Mahalaxmi Refuse Siding.

I attach a formal notice an infringement of which renders you liable to a penalty.

I have, etc.,

....

Executive Health Officer.

NOTICE.

The attention of occupiers of houses and premises is drawn to Section 372 (*e*) and 373 of the Municipal Act which provide respectively (1) that no person shall throw or place any dust, ashes, refuse or rubbish or any excrementitious or polluted matter on any street, or in any place not provided or appointed for this purpose under Section 367 or 368; and (2) that if it shall be shown that dust, ashes, refuse or rubbish or any excrementitious or polluted matter has or have been thrown or placed on any street or place in contravention of clause (*e*) of the last preceding Section from building or land, it shall be presumed until the contrary is proved that the said offence has been committed by the occupier of the building or land.

Dust-bin carts are placed at the most suitable places for the deposit of refuse.

Any one contravening the provisions of Section 372 (*e*) will be prosecuted.

....

Executive Health Officer.

Frequently, however, on account of the leniency of the magistrate or want of evidence, or some technical detail, prosecution fails, or the fines imposed are so trivial as to be ludicrous, and the efforts of the public health authorities are in vain. Nothing but constant action and support by the magistrates will ever have any effect.

Any relaxation in the efforts of the officials, and the people relapse into their primitive habits.

Sanitary dust-bins are being insisted upon for every house, floor and shop for the deposit of refuse, and a basket or bag for waste paper.

Every person found throwing refuse on to the street should be fined, and every person spitting in a public place should be prosecuted; any one urinating in a place other than a urinal or latrine and any one misusing a latrine severely punished.

In a milch cattle stable, the washing place for the animals is also used by the milkmen for their domestic ablutions, and it is common to see a man wash himself, his clothes and his throat in the same place as he cleans his vessels in, using the waste water, sand and cow-dung, &c., wiping out the vessel with a wisp of litter from the cowshed.

Every milkman or milkseller found cleaning his pots with anything but clean water should have his license taken away.

These are matters which have to be considered when applying practical sanitary methods in the East and the best way to apply them is by steady insistence on the regulations, assisted by instructions from the sanitary staff and male and female health visitors coming in touch with the people and the support of the educated classes.

Points to be remembered in connection with the Collection, Removal and Disposal of Refuse. (Town Sweepings).

1. The amount of refuse per head is greater in bulk in Indian cities than in European cities.
2. The refuse is lighter in the dry season but decomposes more rapidly.
3. Refuse should be removed twice a day in India.
4. It should be disposed of as quickly as possible.
5. The amount per annum per head of the population in large cities in India is about 7 cwts.
6. The custom is for the people to throw all refuse on to the streets or passages; this should be prevented by notices and prosecutions.

7. Sanitary dustbins should be provided for compounds; and boxes or baskets for each floor of the house occupied by the poorer classes.
8. The refuse when collected should be taken to the place of disposal at once.
9. Each district should be divided up into areas, with an Inspector, Mukadam and gang of coolies; all carts should have covers.
10. The work should be regularly checked,—trips marked at the depot.
11. The refuse, if disposed of by reclaiming waste land should be covered over at once with 6 inches of dry earth.
12. The reclamation ground should be well away from inhabited houses.
13. Sprinkling the refuse with pesterine will prevent the breeding of flies.
14. Land thus reclaimed should be cultivated at a profit.
15. Destruction of refuse by incinerator is the best and cheapest method of disposal.
16. To calculate the number of carts, bullocks and labour staff necessary, the following data will be required:—
    The population, amount of refuse to be destroyed, distance to place of disposal.
17. A cart drawn by a pair of bullocks will carry about 8 cwts. of refuse, and can make 4 trips of 3 miles each in one working day.
18. One destructor cell will destroy 8 to 10 tons of refuse in 24 hours.
19. A population of 50,000 persons will produce domestic refuse at the rate of 40 tons a day.
20. A four-cell destructor capable of destroying this amount of refuse will cost £ 5,000 to £ 6,000.

CHAPTER III.

COLLECTION, REMOVAL AND DISPOSAL OF SEWAGE.*

The subject of the collection, removal and disposal of sewage in India is one of the most important the sanitary official has to deal with, as well as the most difficult. No matter whether the place involved is a village or a growing town or a large city, the all-pervading presence of the subject crops up at every turn.

The effect on public health of the conservancy system is enormous, beginning with the persistent smell of fæcal matter, human and animal, in and around the houses, up to the pollution of the food or water supply of a large town, or the transference of disease by flies or other insects.

To place the collection and disposal of human and animal excrement under proper control is one of the first principles of practical sanitation in India. It means a reduction in the sickness-rate, reduction in the mortality and an improvement in the condition of the people, morally, physically and hygienically.

Badly constructed trenches for the disposal of excreta and want of supervision in mofussil towns mean the propagation of disease by the dissemination of germs and parasites, by flies and dust reaching the person, his food, milk or water; dogs, cattle, sheep and pigs contract and convey intestinal worms to the human being, and while the sun has a drying and disinfecting power, the high winds disseminate the germ-laden dust. The majority of towns in India suffer from a form of dysenteric diarrhœa due to this pollution of food or water.

Coming to towns which are drained or partially drained, but where only few of the houses are connected, as is the case in the majority of towns in India, the sickness caused by the existing system is impossible to estimate. The open drains receive the contents of the overflowing privy receptacles, the

* A glossary of technical terms is added at the end of the Chapter.

semi-fluid matter percolates through the soil or lies in the open drain and forms a breeding and feeding ground for flies, rats, mosquitoes and vermin. Even in houses, where water-closets exist, it is the custom for the same sweeper to attend to many houses either to clean the pan or wash the seat and bath. This is done with the same brush or cloth in several houses and it is easy to imagine the possibility of disease being spread in this way.

Any attempt at improving the sanitation of a growing town or city will never succeed unless the collection, removal and disposal of night-soil is dealt with in the strictest and most practical manner: the collection of the excreta at regular intervals in a systematic way and the disposal either by proper trenching, incineration or a suitable system of drainage.

AMOUNT OF EXCRETA AND COLLECTION.

Experiments on Bengali prisoners gave an average bowel excretion of 12 ounces or .75 lb. due to the large bulk of vegetable diet eaten by Hindus. This confirms the observations of Dr. Hewlett in Bombay. The volume is due to the proportion of water it contains. In addition to this there are 40 ounces of urine, and the ablution water which must be added, is estimated at 40 ounces per head of the population.

In Bombay, in those parts where the houses are not on the water-closet system, 2 lbs. per head per day for each adult and 1 lb. for each child is the amount of excreta estimated to be actually removed, inclusive of urine and part of the ablution water in the Indian population; a fairly large percentage of the urine and ablution water and fæces passes off into the drain and cannot be collected or soaks away owing to defects in the drains and pipes.

Fresh fæcal matter from healthy persons, living on a mixed diet, has an acid reaction when mixed with urine, and this it retains for a considerable time; it then becomes

alkaline from ammonia. If free from urine, it usually decomposes slowly and in hot weather often dries on the surface, and subsequently changes but little (in England) for some time. In India, it is reduced to powder by the alternate action of sun and dew, and falls into the ground or is dispersed by the wind.

An adult male, living on a mixed diet of animal and vegetable food, passes 4 ozs., by weight, of solid excreta daily.

A daily average for a mixed population of men and women and children, on a diet of animal and vegetable food, may be taken at 2½ ozs. solid and 40 ozs. urine.

From the analysis of the solid and fluid excrement of all nations, sexes and ages made by various authorities, the annual produce of the four principal ingredients found, per head, is as follows :—

——	Fæces.	Urine.	Total.	Value.
	Pounds.	Pounds.	Pounds.	Shillings.
Ammonia (Nitrogen)	1.49	9.38	10.87	7.3
Phosphate of Lime (Phosphoric Acid)	2.00	2.80	4.80	1.7
Potash	0.25	1.08	1.33	0.7
Organic substances	10.51	22.49	33.00	0.7
TOTAL ..	14.25	35.75	50.00	10.0

The fertilising value of excreta per annum per head of the population living on a mixed diet is stated to be equal to raising as much grain as 75 lbs. of guano, and equal to increasing the yield of grain by 3.21 bushels per acre in addition to what the land would yield without manure.

THE PRIVY SYSTEM.

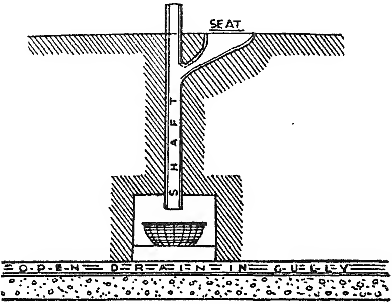
Different methods are being followed by the inhabitants of India in different places for getting rid of the night-soil.

The commonest method adopted in villages and towns is to use the open fields or at a sea-side place, the sea-shore.

In other cases, trenches are cut in the ground into which earth is thrown after use.

An improvement over the preceding methods is to use a stone or earthen squat-seat with or without a receptacle.

An improved modification of the above is the privy, in which the person squats on a cemented platform, the urine and fæces being discharged on to a sloping shoot of iron or cement or glazed earthenware into a receptacle.



OLD FORM OF BASKET PRIVY.

Various patterns of these are on the market and much improvement has been made in them of late.

The receptacle may be of basket work, iron or earthenware.

It is the custom for the majority of Indians to use ablution water and this adds to the quantity of matter to be removed.

Forms of seats and receptacles have been designed to separate the liquid from solid matter; this is desirable but rarely carried out. Fæces and urine combined decompose more readily than when separated.

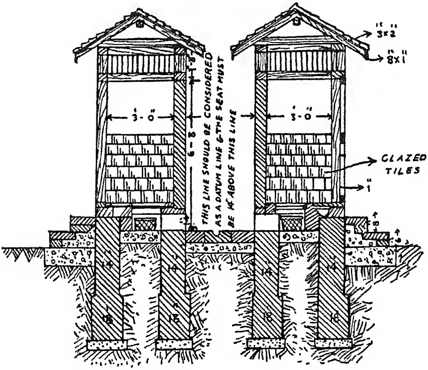
In India there is no dry earth system as known in European cities; it is rare to find outside Military Cantonments any form of privy in which dry earth or ashes are added to the excreta immediately after the usé of the privy.

In practice this method is found successful in public institutions where there is no sewage system. The important thing is the addition of dried earth 1 lb., each time the pail is used. In drying, the earth should not be heated so as to destroy nitrifying organisms which disintegrate the night-soil or humify it. The material must be tolerably dry. The action is ærobic.

The objects to be attained in providing privy accommodation in places where sewers do not exist are :—

1. Position of latrines should be away from the buildings and to the leeward side.

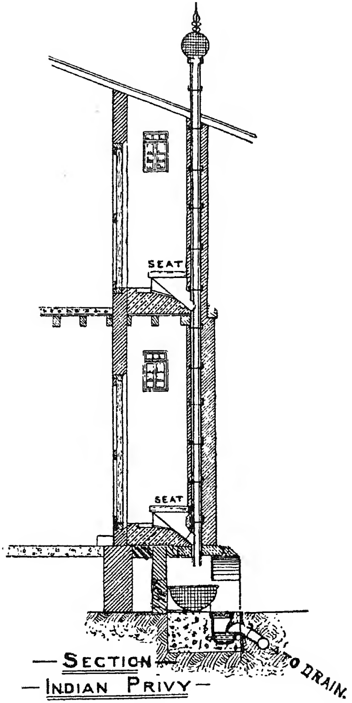
2. Impervious floor and wall and seat or platform of impervious material.



BASKET SYSTEM PRIVY—CROSS SECTION.

3. Water-tight receptacles capable of holding the daily excreta of the household.

4. Facility of removal of contents once a day at least.



— SECTION —
— INDIAN PRIVY —

5. Ventilation of the privy.

6. Washing and cleansing of receptacles.

The position of the cess-pools should be away from buildings and wells and affording facilities for access and emptying.

In sewered towns where the latrines are not connected with the sewer, receptacles have to be provided and the contents removed to pail depots by hand or carts.

The essence of practical sanitation in all countries is the immediate removal of all waste products. This should be more particularly the case in tropical countries, where decomposition sets in more rapidly.

In towns where the houses are built of two or more storeys, with the privies on each storey the system is one of the most insanitary features to be met with. In Bombay, there were hundreds of houses in which privy seats were placed one above the other at one end of a dark passage within the building. A number of them are yet to be seen. The platform or seat of the privy is made of cement or stone or glazed earthenware in which there is a slit about 6 inches wide and a shoot directly connected to an iron, earthenware or stone shaft common to all the privies on the several floors. This shaft opens out below into a square compartment (called trap) at ground level and directly over a basket or iron receptacle placed therein. The trap is fitted with a door, to prevent the receptacle being viewed by passers-by or residents in the adjoining buildings. The excreta discharged into the shaft drop into the receptacle 30 to 60 feet below with a splash. The shaft becomes coated with filth, the trap below is smeared with particles of excrementitious matter and the stink that emanates from the privy is most repulsive. The presence of the decomposing filth attracting flies is a serious danger to health, apart from the constant foul smell and pollution of air of the rooms.

The custom of removing the excreta by hand is not only objectionable but constitutes a serious danger. The night-soil remains in the receptacle for hours together and makes a breeding place for flies and other vermin. Gases evolved from the decomposing filth adhering to the seats and sides of the shaft, enter freely into the house. The immediate surroundings in the area of the privy range at ground level are always wet with particles of night-soil scattered about and floating in the open channel drain immediately alongside. The sight of the halalkhore moving along the public streets with his loaded basket leaves much to be desired.

The remedy lies in the entire abolition of the privy system. This system is not merely insanitary; it offends all sense of decency and undoubtedly tends to lower the moral standard of the staff engaged in the work. The existence of privies largely accounts for the spread of Enteric fever and epidemics of summer diarrhœa. The process of cleansing and removal is an annoyance and an affront to the eyes and nose, whilst the cost of such cleansing is unduly high, and much in excess of that which is entailed where superior means of collection and removal exist.

DISPOSAL OF NIGHT-SOIL.

The night-soil collected in the conservancy system may be disposed off by one of the following ways :—

(*i*) Dumping into the sea or river. This must be done at a selected spot from which the excreta will not be washed ashore either by the tide or the wind.

(*ii*) By incineration.

(*iii*) Trenching.

- (*a*) Shallow.
- (*b*) Deep.

Incineration.—This system requires the separation of the solid from the liquid excreta and a sufficient supply of

horse-litter or dry rubbish of an inflammable character. It can be practised in small institutions like jails and hospitals. The objection urged against its general application are :—

(*a*) That the rubbish in civil stations is usually of such a character that it will not burn well.

(*b*) That it is usually damp and in the rains wet and requires long storage.

(*c*) That constant supervision is required.

(*d*) That no income accrues to the Municipality from the sale of rubbish and night-soil, although the expenses of cartage are diminished.

(*e*) The smell of incinerators.

Trenching.—When properly carried out, this system is one of the best for the disposal of night-soil in small towns and villages in India. The prime requirement is a sufficient area of land, suitably situated in the neighbourhood of the town. The soil for effective trenching should be loamy and porous and fairly well-drained naturally. The rainfall in the locality must not be heavy as trenching has to be carried out throughout the year and permits of no interruption. The trenching ground should be situated at least half a mile away from the residential area and properly laid out according to the method of trenching to be adopted. Similarly there should be no sources of water supply like tanks or wells, near the trenching ground as they are likely to be contaminated. A row of trees may be planted along the side of the land adjacent to the town. Proper roads should be constructed from the town, leading to the trenching area. Arrangements should also be made for the supply of sufficient amount of water on the spot for washing the night-soil carts and other receptacles.

Trenching may be carried out on the shallow or the deep system. The former method is the better of the two but

requires a larger area of land. Deep trenching is only undertaken for the purpose of economising on land. A larger amount of night-soil can be dumped into a deep trench no doubt, but it suffers from the disadvantage that there is greater likelihood of nuisance arising with less purification of the night-soil. The organisms which simplify and render harmless the constituents of the night-soil are confined to the superficial layers of the soil and, therefore, with the deep trenching method, purification of excreta will not only be delayed but unless properly supervised, offensive gases may be given off, due to decomposition of sewage, causing a nuisance to the neighbourhood.

Shallow trenching.—The area should be divided into 3 plots, each plot capable of dealing with the excreta of the whole year; one plot should be used every year in succession. The length of each trench would be decided by the length of the plot of land. The depth may vary from 9 inches to 2 ft.; on an average, it should be 18 inches. Similarly, the width may vary from 18 inches to 2 ft. The trenches should be dug in straight parallel lines 2 ft. apart from one another. The amount of night-soil to be placed in each trench may vary from a layer of 3 inches in the trench with the minimum depth (9 inches) to 1 ft. in the trench with the maximum depth (2 ft.). Immediately after the night-soil is tipped in, the trenches should be filled in with the excavated earth. They would then present the appearance of lines of mounds, the elevation indicating the site of the trench. The earth will subside in a few months to the general ground level. Night-soil thus trenched will usually be resolved into harmless products in about six months. As the rapidity with which such changes are effected depends largely upon the character of the soil, it is desirable in every case, to ascertain, by an experimental excavation whether the contents of a trench are dry and inodorous. The contents of such trenches are in demand by cultivators as they possess high manurial value.

Each plot of land may thus be used for one year after which it should be levelled and a few crops such as those of maize, tobacco, etc., taken off it. Land thus treated may, therefore, be trenched one year and crops obtained off it for the succeeding two years.

A modification of the shallow trenching system introduced by Col. Thornhill at Bareilly may be undertaken in places where there is no sale for the resulting manure. The trenches are shallow but wider and of a particular specification, *viz.*, $16' \times 5' \times 1'$ with 6 inches between each trench and 6 inches between each line of trenches. The soil removed is thoroughly pulverised (an essential condition) and 2 inches is returned to the trench into which the contents of one or more night-soil carts are tipped. If the night-soil is mixed with earth, the whole of the remaining earth need not be returned. Rich crops of potatoes and tobacco may be obtained by direct cultivation. Land so treated does not require manuring again usually till the fourth year.

Deep trenching.—As an example of this system, the Nasik system may be described. The trenches are dug in stiff soil, which admits of their shapes being retained and they can be used over and over again. The trenches are usually 12 ft. in length, 4 ft. in width and 3 ft. in depth. The length may be increased to as much as 80 ft. depending upon the length of the trenching ground but the breadth should not be more than 5 ft. and the depth, not more than 4 ft. because of the expense of digging the trenches and covering the night-soil subsequently. The night-soil is carried to the trenching ground in carts, which are emptied into the trenches by being tilted backwards. The night-soil is practically liquid and finds its own level in trenches of any length. After the day's excreta are tipped into a trench, a layer of a few inches of kutchra (town-refuse) is lightly sprinkled on the top. It floats on the night-soil and constitutes an efficient seal, thus keeping out flies. During the

next day or two and sometimes even later, in a long trench, there are here and there volcanic eruptions of gas and night-soil through the refuse. A sweeper goes round and patches up these with a shovelful of kutchra. As the night-soil dries, the level of the top of the trenches shrinks. The earth originally excavated can be used to protect the sides of the trenches from running rain water.

The same trench may be used for depositing the night-soil of several days into it. Each day's night-soil has to be sealed with kutchra and the next day's is allowed to run on top of it.

Trenching at Nasik can be carried out all the year round. The monsoon does not interfere with it because night-soil is treated as liquid. If it gets diluted with rain water, it will dry away subsequently and will shrink further.

The night-soil ripened in a year's time, resembles very much the ordinary earth in appearance and is without any smell. It is in great demand by cultivators.

The system is efficiently worked out and there is no smell perceptible near the trenching ground nor is there any fly nuisance.

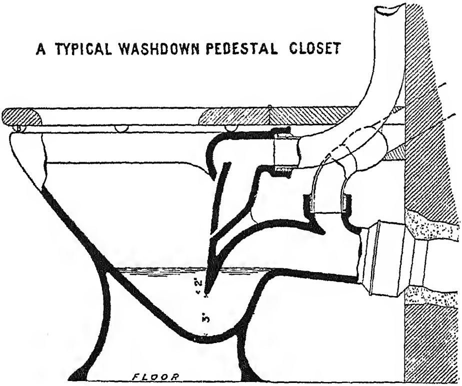
Deep trenching attempted on the lines of the Nasik system, at Ahmedabad and in the suburbs of Bombay has not proved successful, probably because the soil being water-logged was not suitable for the purpose.

THE WATER-CARRIAGE SYSTEM.

The best substitute of the privy system is the water-carriage system. The excreta deposited in a suitable receptacle called the soil-pan are carried away by a flush of water through a system of pipes—the drains and sewers—to the outfall in such a way that there is no nuisance produced either in the house or in the neighbourhood.

The different parts of a water-carriage system are (1) the water-closet; (2) the soil pipe; (3) the house-drain; and (4) the sewer.

(1) The water-closet consists of a soil pan for the deposit of excreta, connected to a bent pipe—the trap, which holds a certain quantity of water for maintaining the water-seal. The trap is connected to the soil pipe. Connected with the soil pan by means of a pipe is a cistern called the flushing cistern, which delivers a certain quantity of water for flushing the water-closet, either automatically or when a chain attached to it is pulled.



The essential qualities of a good water-closet are :—

(1) that it should be made of non-absorbent material; (2) that it should be self-cleansing; (3) that it should be simple in construction and not liable to get into a state of disrepair; (4) that it should not require more than 3 gallons

of water for thorough and effective cleansing; and (5) that it should have a good trap with an efficient water-seal.

The trap connected to the soil-pan may be of the P or S variety but should be such as to hold a water-seal of $1\frac{1}{2}$ to 3 inches. It should be self-cleansing with the available flush of water.

The capacity of the flushing cistern should be such as to hold 2 to 3 gallons of water. The pipe connecting the flushing cistern with the soil-pan should be about $1\frac{1}{4}$ inch in diameter. The flushing water should on no account be taken directly from a tank or service-pipe which supplies water for household purposes but each closet should have its own separate flushing cistern.

Flushing cisterns should be placed at least 4 feet above the level of the closet-seat. They should be made of iron and provided with siphon action. A small pull of the chain puts the siphon into action when the whole contents of the flushing cistern are discharged into the soil-pan. Flushing cisterns should be supplied from a tank the water from which is not used for any other purpose. Water-closets should always be placed against the external wall of a building. Each closet should be provided with a window, opening into the external air.

(2) Soil-pipes are pipes for conveying the excreta from the water-closet to the house-drain. They should be air and water-tight, and so placed as to be capable of being inspected throughout their course. Consequently they are situated outside and against the external wall of the building. Soil-pipes may be of drawn lead or of heavy cast-iron coated with Angus Smith's Solution. A diameter of 3 inches for a soil-pipe is considered sufficient. For the purpose of ventilation, the soil-pipe should be continued upwards without diminution of its diameter and without bends and angles to such a height above the roof and in such a position as will permit

a safe outlet for foul air. The soil pipe should not be connected with a rain-water pipe or waste-water pipe of any bath, lavatory basin or sink other than a slop-sink. The open end of the soil-pipe should be fitted with a suitable grating or wire-dome to prevent birds from building their nests in it or the introduction of any other thing likely to cause an obstruction to the pipe.

When several water-closets on different floors discharge into the same soil-pipe, the traps of the lower closets are likely to be unsealed when a water-closet on a higher floor discharges its flush. To prevent this, anti-siphonage pipes are provided between the trap of each water-closet and the soil-pipe. The anti-siphonage pipes coming from different closets are connected up to one single pipe which is either carried upwards separately by the side of the soil-pipe or connected to the soil-pipe above the level of the highest water-closet.

The main soil-pipe is connected by a stone-ware rest bend to the house-drain which is supported on a bed of concrete. No trap should intervene in or between the soil pipe and the drain with which it is connected.

The connections between the soil-pipe and the trap and the trap and the water-closet should be made in such a way as to render them effective for work, and the jointings and materials used should be as prescribed in the London County Council Bye-laws, page 173. The points to be remembered in respect of connections and joints are summarised below :—

(*a*) The connection of a lead pipe with a lead trap should be by a fused, burned or wiped plumber's joint.

(*b*) The connection of a lead pipe or trap with a copper pipe, or trap should be by a wiped plumber's joint.

(*c*) The connection of a lead pipe or trap with an iron pipe, trap or drain should be by means of a thimble or flanged ferrule of copper, brass or other suitable

alloy connected with the lead pipe or trap by a wiped plumber's joint and with the iron pipe, trap or drain by a joint made with a gasket of hemp or yarn and metallic lead properly caulked.

(*d*) The connection of a lead pipe or a trap with a stone-ware pipe, trap or drain should be by means of a thimble or ferrule as described in (*c*) connected with pipe or trap by a wiped plumber's joint and with the stone-ware pipe, trap or drain by a joint made with a gasket of hemp or yarn and cement.

(*e*) The connection of a copper trap with a copper-pipe should be by means of a union nut or flanged coupling.

(*f*) The connection of a copper pipe or a trap with an iron pipe, trap or drain should be by means of a thimble or flanged ferrule of copper, brass or other suitable alloy connected with the copper pipe, or trap by a union nut or flanged coupling and with the iron pipe, trap or drain by a joint made with the gasket of hemp or yarn and metallic lead properly caulked or with flanges securely bolted together with some suitable insertion.

(*g*) The connection of a copper pipe or trap with a stone-ware pipe trap or drain should be by means of a thimble or ferrule of copper, brass or other suitable alloy connected with the copper pipe or trap by a union nut or flanged coupling and with the stone-ware pipe, trap or drain by a joint made with a gasket of hemp or yarn and cement.

(*h*) The connection of an iron pipe or drain with an iron trap should be by a joint made with a gasket of hemp or yarn and metallic lead properly caulked or with flanges securely bolted together with some suitable insertion.

(*i*) The connection of an iron pipe, trap or drain with a stone-ware pipe or drain should be by a joint with a gasket of hemp or yarn and cement.

Much progress has already been made in Bombay in this direction, as all new houses and also the Public Sanitary Conveniences have now such accommodation on the full water-carriage system; as regards the old existing privies, action is being proceeded with for their conversion. The Bombay Corporation has succeeded in converting 26,000 privy seats into water-closets by a subvention scheme started in 1929, spending Rs. 18,00,000 in helping the house-owners in meeting a part of the expense.

The argument that water-closets get out of order and are not suitable to Indians is overdone. A suitable form of water-closet with automatic flush and proper supervision is practicable in the majority of houses in large Indian towns.

The objections urged against water-closets in Indian towns are owing to :—

(1) the want of sufficient supply of water, (2) the habits of the people, (3) the inefficiency of the sewers and (4) the cost.

Without a proper supply of water, a water-closet connected with the sewer is undoubtedly not free from danger. Arrangements should be made to keep the water-closet properly supplied with water by providing suitable storage tanks properly covered and fitted with automatic fittings and not directly connected with the water-closet. The size of the tanks necessary can be estimated by taking the census of the building, allowing for one day's supply and calculating 5 gallons per head per day for water-closet purposes.

(3) House-drains convey the excreta discharged from the water-closet by the soil-pipe, waste-water from baths and sinks and also a certain amount of rain-water. They are meant to convey the waste-products to the sewer as

expeditiously as it is possible for a flush of water to do and it is necessary in constructing drainage-works that proper care should be exercised in the selection of the materials as well as in the laying of drains.

As regards the materials, the house-drain may be made of either glazed stone-ware pipes or cast-iron pipes. The stone-ware pipes to be used should be well burnt and salt glazed which renders them more durable. They should preferably have withstood the hydraulic pressure test before leaving the factory. Under these circumstances they are as good as the best cast-iron pipes, besides possessing an additional advantage over the latter in being incorrodible.

Stone-ware pipes are usually made in 2 feet length and the most suitable thickness is considered to be,

7/16″	for	3″	internal diameter.
½″	,,	4″	,,
9/16″	,,	5″	,,
5/8″	,,	6″	,,
11/16″	,,	7″ & 8″	,,
¾″	,,	9″	,,

Cast-iron pipes to be used for drainage works must be of a uniform thickness and be free from flaws, cracks or sand-holes. They should not be brittle but allow of easy cutting, chipping, drilling, etc., and when struck with a hammer, should emit a clear and bell-like sound. The advantages claimed for these pipes are—(1) greater strength, (2) greater length (6′ to 9′), (3) greater rigidity, (4) fewer and more reliable joints, they being of molten lead and (5) more expeditious laying.

Cast-iron pipes before being laid should be treated either with Angus Smith's Solution or by the Barff process.

The best thickness for 9′ cast-iron pipes should be as follows :—

5/16″	for	3″ diameter.
⅜″	,,	4″, 5″ and 6″ diameter.
7/16″	,,	7″, 8″ and 9″ diameter.

Drains should be laid in straight lines with suitable fall from one end to the other and the socket-end of each segment of the pipe directed towards the house should receive the spigot-end of the segment above. The usual size of a main house-drain is 6 inches but branch drains rarely exceed 4 inches in diameter. The fall should not be less than 1 in. 40 or 60. The joints between the different segments of the drain should be properly made. In case of stone-ware pipes, the joint should be made with a jacket of hemp or yarn and cement; if cast-iron, it should be with a jacket and metallic lead properly caulked in.

Stone-ware drains should be laid on a bed of concrete at least 6 inches thick so as to prevent subsidence; the concrete should project on each side of the drain to a width of not less than 6 inches.

Branch drains should meet the main-drain obliquely in the direction of the flow of such drain and as near as possible to the invert of the drain. Drains should not be constructed so as to be within or under any building but where it is impracticable to do otherwise, precautions should be taken to protect the pipe. As far as possible, iron pipes alone should be used. They should be laid on a bed of concrete as mentioned above. If the use of stone-ware pipes is unavoidable, they should be constructed in a bed of concrete and should have in addition a casing of concrete on the upper surface, at least 6 inches thick. When the pipe passes beneath a wall, it should be protected at this part by means of a relieving arch or other support which does not bear on the drain.

Manhole inspection chambers should be provided in the course of a drain at suitable intervals which should not exceed 100 feet. They allow of inspection and cleansing in case the drain becomes choked.

As far as possible drains should be in straight lines but where a change in direction is necessary, it should be made by means of a curved pipe. Manhole inspection chambers should be provided at these points also and branch drains may open

into the main-drain at these sites. Where an increase in the diameter of the house-drain is necessary to accommodate the additional amount of sewage flowing in from the branch drains, it should be secured by means of a taper or diameter pipe.

An inspection chamber should also be constructed at the junction of the house-drain with the sewer. The house-drain in the form of a half channel pipe and embedded in concrete passes on the floor of this chamber and branch drains may be made to open into it, also as half-channel pipes. The end of the house drain is connected with the sewer through an intercepting trap, with a water-seal of 2 to 3 inches. The water-seal is meant to prevent the sewer air from entering the house-drain and thence into the house, but since sewer air is not more dangerous than air from the house-drain, this does not seem to be an important use of it. It is more useful to prevent sewer rats from entering the house-drain. The intercepting trap is provided with a raking arm or clearing eye which is ordinarily kept closed by means of a tight-fitting cover. The side walls of the inspection chamber are rendered impervious with cement or by being lined with glazed tiles or bricks set in cement. For the purpose of the ventilation of house-drain, a pipe is carried upto above the ground-level from the distant end of the inspection chamber. The upper end of the pipe is guarded by a mica-flap valve set in a metal case. The mica-flap is so arranged that it allows air from outside to enter the inspection chamber and the house-drain but closes automatically, in case gases from the house-drain try to escape through it. This pipe therefore acts as an inlet ventilator, the outlet ventilator being the soil-pipe, carried up above the eves of the house. All man-hole and intercepting inspection chambers should be provided with suitable iron covers either groved or bolted.

PRACTICAL APPLICATION OF THE FOREGOING.

It will be convenient at this point to discuss the application of these rules to the different classes of houses in cities and towns in India.

Reference has already been made to the various forms of privy accommodation, and how the excreta and sullage water are removed to the sewer. In many parts of every city in India there are no sewers available and recourse must be had to cesspits for sullage water. Sullage water may be described as the waste water from cook-rooms, bathrooms and nahanis, which does not necessarily contain excreta, though in India it would be difficult to eliminate fæcal matter as an ingredient of sullage.

The classes of houses to be met with are—

1. Those on European style with water-closets and baths drained and connected with the sewer on the modern system, as already described.

2. Bungalows with gardens. The waste water from baths and stables and kitchens discharges into drains and sewers; the servants' water-closets are connected with the sewer, the tenants of the bungalows using commodes which are emptied by hand.

3. Indian houses with water-closets and bathing accommodation separated from the houses. all connected with the sewer.

4. Indian houses with nahanis inside the house, and with the privy system, on basket; the contents of the privy receptacle are removed by hand; the waste water from bath, kitchen, nahani or mori and the overflowings from the privy receptacle discharge into covered pipe drains in the gully or passage between the houses and into the house drains and sewer.

5. Similar houses but where the sullage and overflow from the privy receptacle pass into an open drain and then into the house drains and sewer.

6. Indian houses on the privy receptacle system with a cesspit, the sullage from the kitchen, nahani and bath discharging also into a cesspit. In this case the sullage water

should be kept separate from the privy, and both cesspits should be emptied daily.

The Municipal Act provides that where there is a sewer within 100 feet of the premises, the owner must connect his drain with the sewer. Where there is no sewer within 100 feet, a cesspit must be provided into which the liquid from the privy receptacles and kitchen waste should discharge by means of a 4-inch pipe properly laid.

The capacity of a cesspool for houses of this kind in India should be sufficient to hold 24 hours' flow. The cesspool should be placed as far as possible from the dwellings, and ventilated with a 3-inch pipe, carried well above the highest window. The cesspool for privies should be separate from that for nahanis and should have a capacity of 3 cubic feet per privy seat, with a minimum of 25 cubic feet, and should be regularly emptied once in 24 hours. The cesspit should be constructed of brick laid on concrete and internally rendered with a ½ inch layer of cement and sand. Its walls should be brought up 6 inches above the surface of the ground, so that surface water should not be able to enter it, and covered with an air-tight cover to prevent noxious odours. Cesspools for sullage water from bath rooms should be similarly constructed, and if the water is used in the garden, care should be taken to see that they are regularly emptied and properly covered, so as to prevent the breeding of mosquitoes.

PUBLIC SANITARY CONVENIENCES.

The Municipal Acts in force in India lay down that the sanitary authority shall provide and maintain, in convenient situations, and on sites vesting in the Corporation, water-closets, latrines, privies and urinals, and other similar conveniences for public accommodation.

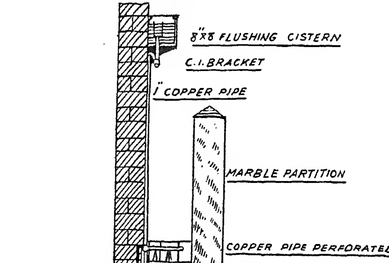
It devolves on the Health Department, as a rule, to advise on the number, site, capacity and form of public

conveniences, and in doing this the following points have to be considered :—

In very few cities in India is it possible to have a latrine for every house.

The Act empowers the sanitary authority to insist on the provision of privy accommodation for each house. The Bombay and Calcutta Municipal Acts do so, and the Public Health Act, England (1875), but with modifications. For example, if the privy accommodation, already provided, is common to several houses and is sufficient, or if there is

— AUTOMATIC FLUSHING URINAL —



—VERTICAL SECTION—

sufficient Municipal accommodation available in the neighbourhood, the sanitary authority need not insist on separate

accommodation for each house. These circumstances then have to be considered, and to meet the requirements of the people it will be necessary to decide what Municipal public accommodation is required for different localities—

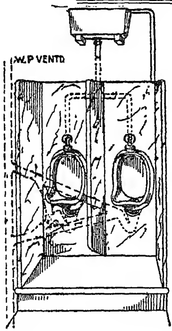
1. Where no drains and sewers are available and the night-soil has to be carried to a trenching ground.

2. Where sewers are available but water is not sufficient for a constant supply at full pressure, and the night-soil has to be carried to the pail depot.

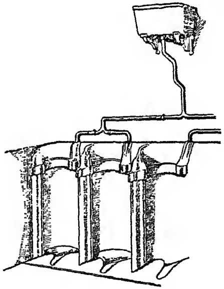
3. Where the water-closets can be on the full flushing system.

Amongst the poorer classes, in mill districts, docks and localities occupied by daily labourers, the houses are provided with latrines common to two or more. Mills and factories must provide latrines in some form or other.

— IMPROVED URINALS —



WIDE-FRONTED BASIN URINAL



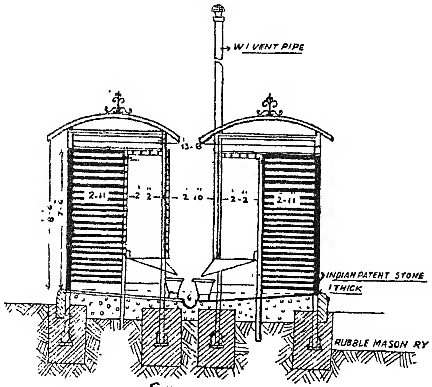
WHITE GLAZED SEMI-CIRCULAR BACK IN ONE PIECE

The bye-laws to be made under Section 6 of the Housing Act of 1925, England, require the provision of closet accommo-

dation, "adequate for the use of and readily accessible to each family in houses intended or used for occupation by the working classes".

The early hours of the morning, from 4 to 8 are the time when the latrines are most used, and, as there will be a rush for the latrines in the compounds of the houses, public latrines will be in demand. A visit to a latrine will probably take 4 minutes, therefore 15 person can use one seat every hour or 60 in the first 4 hours; and on this basis, 15 seats will be sufficient for a population of 1,000 because the whole population would not require to use them at the same time, but only those who cannot be accommodated at their houses or works. For large blocks of labourers' dwellings, or mills or factories, more accommodation is required, and in Bombay

— CRAWFORD SYSTEM LATRINES —



— SECTION —

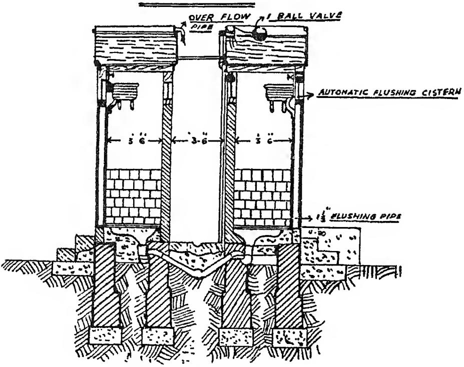
it is usual to ask for 1 seat for every five rooms, or 20 persons, in a chawl, house or mill, and although there is no bye-law

to that effect, it has been so long the custom that it is now recognised by architects and the Magistrates' Courts. In the Factory Act, 1 seat for 50 persons is laid down, but this is not sufficient, unless on the water carriage system, even when separate urinals are provided.

Public latrines and urinals should be provided at suitable places, for example, outside theatres, the neighbourhood of docks and railway stations, tram terminii, burial grounds and markets, &c., stables and large blocks of dwellings.

Public conveniences on the water carriage system should be tiled inside and paved outside for a distance of 6 feet all

— LATRINES ON WATER CARRIAGE SYSTEM —



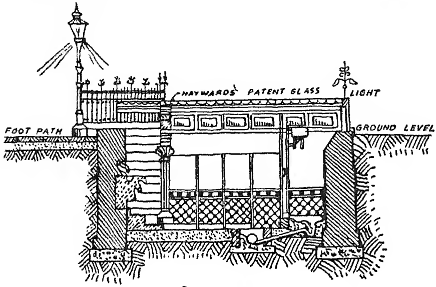
— CROSS SECTION —

round, and provision made for washing the surrounding pavement.

No matter what accommodation is provided, fouling of the roads in the neighbourhood of latrines and urinals always takes place in India. The inside of urinals and latrines is not only missued, but the outside as well.

The automatic flushing urinal (see page 166) is a contrivance which is easily kept clean and there is hardly any smell in its neighbourhood.

— COMBINED UNDERGROUND PUBLIC CONVENIENCES —



— SECTION —

The improved patterns of urinal (see page 167) are an improvement over the above and may be used instead. They occupy less space (basin urinal) and some of them are made in one piece for convenience of fitting.

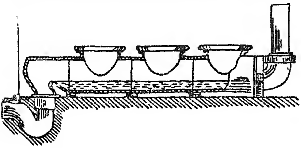
The Crawford System latrines (see page 168) are comparatively cheap and are to be recommended where water carriage system does not exist. Latrines on the water-carriage system (see page 169) are more sanitary than above and may be substituted where possible.

Underground public conveniences (see above) are useful in the busiest thoroughfares of the city. They are rather expensive.

Trough pattern latrines are used in large establishments such as factories, schools, barracks and hospitals on account of ease and economy. Each latrine consists of a glazed stoneware trough, at the lower end of which is a weir for holding a sufficient amount of water to cover its bottom for its whole length. The trough shows a slight fall towards the drain

and is connected with it by a siphon trap. Each seat over the trough is in a separate compartment. The latrine is flushed by means of an automatic flushing tank which should hold sufficient water to flush the trough completely.

— TROUGH PATTERN LATRINES —



SANITARY FITTINGS.

The principles underlying all regulations for sanitary fittings are the prevention of foul air or liquid escaping from the house drain or sewer into dwellings or open spaces close to dwellings, and the through ventilation of soil pipes, drains and sewers. For this purpose strict regulations have been drawn up.

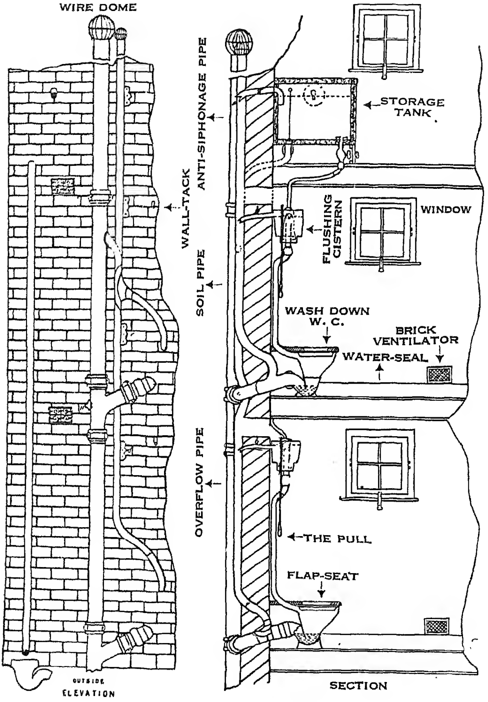
The bye-laws in force in the London County Council and in the Bombay Municipality are given below.

It must be understood that the condition of the two cities varies greatly. In India the building and drainage regulations are not so complete as in England, though they are gradually becoming so in Bombay and Calcutta. At the same time conditions exist, due to climate and the habits and customs of the people and the water supply, which have to be competed against and a knowledge of these is necessary for the proper understanding of the regulations in force.

The rules as to how the water-closet should be fixed should not vary.

The fittings of a completely fitted water-closet should be the same everywhere and the sketch given is of the most modern type, and the instructions as to connection the most up-to-date.

To meet demands and to prevent nuisance, many modified forms of water-closets are adopted in India.



SANITARY FITTINGS

LONDON COUNTY COUNCIL REQUIREMENTS.

[*Extracts from By-laws made by the London County Council under the Public Health (London) Act*, 1891.]

Water-closets.—Every person who shall hereafter construct a water-closet shall construct it in such a position that one of its sides at the least shall be an external wall which external wall shall abut immediately upon the street, or upon a yard, or garden, or open space of not less than 100 square feet of superficial area, measured horizontally at a point below the level of the floor of such closet. He shall not construct any such water-closet so that it is approached directly from any room used for the purpose of human habitation, or used for the manufacture, preparation, or storage of food for man, or used as a factory, workshop or work-place.

He shall construct such water-closet so that on any side on which it would abut on a room intended for human habitation, or used for the manufacture, preparation, or storage or food for man, or used as a factory, workshop or work-place, it shall be enclosed by a solid wall or partition of brick or other materials extending the entire height from the floor to the ceiling.

He shall provide any such water-closet that is approached from the external air with a floor of hard, smooth, impervious material, sloping to the door half-inch to the foot.

He shall provide such water-closet with proper doors and fastenings.

Every person who shall construet a water-closet in connection with a building, whether the situation of such water-closet be or be not within or partly within such building, shall construct in one of the walls of such water-closet which shall abut upon the public way, yard, garden, or open space, as provided by the preceding by-law, a window, of such dimensions that an area of not less than two square feet, which may be the whole or part of such window, shall open directly into the external air.

He shall, in addition to such window, cause such water-closet to be provided with adequate means of constant ventilation by at least one air brick built in an external wall of such water-closet or by an air shaft or by some other effectual method or appliance.

Every person, who shall contruct a water-closet in connection with a building shall furnish such water-closet with a cistern, of adequate capacity for the purpose of flushing, which shall be separate and distinct from any cistern used for drinking purposes and shall be so constructed, fitted and placed as to admit of the supply of water for use in such water-closet, so that there shall not be any direct communication between any service pipe upon the premises and any part of the apparatus of such water-closet other than such flushing cistern.

Provided always that the foregoing requirements shall be deemed to be complied with in any case where the apparatus of a water-closet is connected for the purpose of flushing with a cistern of adequate capacity which is used solely for flushing water-closets or urinals.

He shall construct or fix the pipe and union connecting such flushing cistern with the pan, basin or other receptacle with which such water-

closet may be provided, so that such pipe and union shall not in any part have an internal diameter of less than one inch and a quarter.

He shall furnish such water-closet with a suitable apparatus for the effectual application of water to the pan, basin or other receptacle with which such apparatus may be connected and used, and for the effectual flushing and cleaning of such pan, basin or other receptacle, and for the prompt and effectual removal therefrom and from the trap connected therewith of any solid or liquid filth which may from time to time be deposited therein.

He shall furnish such water-closet with a pan, basin or other suitable receptacle of non-absorbent material and of such shape, of such capacity, and of such mode of construction as to receive and contain a sufficient quantity of water and to allow all filth, which may from time to time be deposited in such pan, basin or receptacle, to fall free of the sides thereof and directly into the water received and contained in such pan, basin or receptacle.

He shall not construct or fix under such pan, basin or receptacle any "container" or other similar fitting.

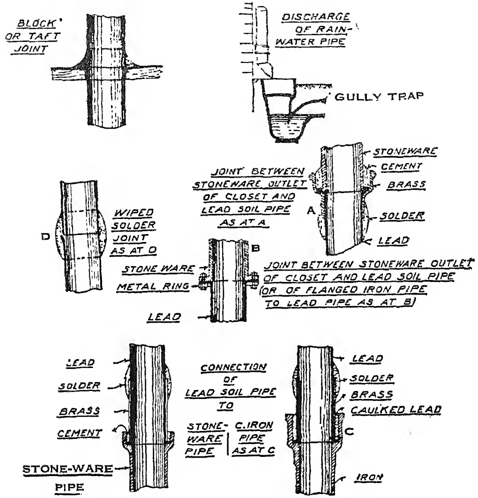
He shall construct or fix immediately beneath or in connection with such pan, basin or other suitable receptacle an efficient siphon trap, so constructed that it shall at all times maintain a sufficient water seal between such pan, basin or other suitable receptacle and any drain or soil pipe in connection therewith. He shall not construct or fix in or in connection with the water-closet apparatus any D trap or other similar trap.

Any person who shall provide a soil pipe in connection with a new building for the purpose of conveying to a sewer any solid or liquid excremental filth, or shall for that purpose construct a soil pipe in connection with an existing building shall, whenever practicable, cause such soil pipe to be situated outside such building, and shall construct such soil pipe in drawn lead or of heavy cast iron. Provided that in any case where it shall be necessary to construct such soil pipe within such building, he shall construct such soil pipe in drawn lead with proper wiped plumbers' joints, and so as to be easily accessible.

He shall construct such soil pipe, whether inside or outside the building so that its weight, if the pipe be of lead, and its thickness and weight if the pipe be of iron, in proportion to its length and internal diameter shall be—

Lead.		*Iron.*	
Diameter.	*Weight per 10ft. length not less than*	*Thickness of metal not less than*	*Weight per 6 ft. length (including socket and beaded Spigot or flanges, the socket not to be less than ¼in. thick) not less than*
1	2	3	4
3½ inches ..	65 lbs.	3/16 inch	48 lbs.
4 ,, ..	74 ,,	3/16 ,,	54 ,,
5 ,, ..	92 ,,	¼ ,,	69 ,,
6 ,, ..	110 ,,	½ ,,	84 ,,

If he shall construct such soil pipe of cast iron with socket joints, he shall cause such joints to be not less than $2\frac{1}{4}$ inches in depth and to be made with molten lead properly caulked, and he shall also cause the annular space for the lead in the case of $3\frac{1}{2}$ inch and 4 inch pipes to be not less than



$\frac{3}{4}$ inch in width, and in the case of 5 inch and 6 inch pipes to be not less than $\frac{5}{8}$ inch in width. If he shall construct such soil pipe with flange joints, he shall cause such joints to be securely bolted together with some suitable insertion.

He shall construct such soil pipe whether inside or outside the building so that it shall not be connected with any rain-water pipe or with the waste of any bath, or of any sink other than that which is provided for the reception of urine or other excremental filth, and he shall construct such soil pipe so that there shall not be any trap in such soil pipe or between the soil pipe and any drain with which it is connected.

He shall cause such soil pipe, whether inside or outside the building, to be circular and to have an internal diameter of not less than $3\frac{1}{2}$ inches

and to be continued upwards without diminution of its diameter, and (except where unavoidable) without any bend or angle being formed in such soil pipe to such a height and in such a position as to afford, by means of the open end of such soil pipe, a safe outlet for foul air.

Any person who shall connect a lead soil pipe, waste pipe, ventilating pipe or trap with an iron pipe drain communicating with the sewer shall insert between such lead soil pipe, waste pipe, ventilating pipe or trap, and such iron pipe or drain, a flanged thimble of copper, brass, or other suitable alloy, and shall connect such lead soil pipe, waste pipe, ventilating pipe, or trap with such thimble by means of a wiped or overcast metallic joint, and shall connect such thimble with such iron pipe or drain by means of a joint made with molten lead properly caulked; provided always that it shall be sufficient if he shall connect the lead soil pipe, waste pipe, ventilating pipe, or trap with the iron pipe or drain in an equally suitable and efficient manner.

Any person who shall connect a stoneware or semi-vitrified ware trap or pipe with a lead soil pipe, waste pipe or trap communicating with a sewer, shall insert between such stoneware or semi-vitrified ware trap or pipe and such lead soil pipe, waste pipe or trap, a socket of copper, brass, or other suitable alloy, and shall insert such stoneware or semi-vitrified ware trap or pipe into such socket, making the joint with Portland cement, and shall connect such socket with the lead soil pipe, waste pipe, or trap by means of a wiped or overcast metallic joint; provided always that it shall be sufficient if he shall connect the stoneware or semi-vitrified ware trap or pipe with the lead soil pipe, waste pipe, or trap, in an equally suitable and efficient manner.

Any person who shall connect a lead soil pipe, waste pipe, ventilating pipe, or trap with a stoneware or semi-vitrified ware pipe or drain communicating with a sewer shall insert between such lead soil pipe, waste pipe or ventilating pipe or trap and such stoneware or semi-vitrified ware pipe or drain, a flanged thimble of copper, brass, or other suitable alloy and shall connect such lead soil pipe, waste pipe, ventilating pipe, or trap with such thimble by means of a wiped or overcast metallic joint, and shall insert the flanged end of such thimble into a socket of such stoneware or semi-vitrified ware pipe or drain making the joint with Portland cement; provided always that it shall be sufficient if he shall connect the lead soil pipe, waste pipe, ventilating pipe or trap with the stoneware or semi-vitrified ware pipe or drain in an equally suitable and efficient manner.

Any person who shall connect an iron soil pipe, ventilating pipe or trap with a stoneware or semi-vitrified ware pipe or drain communicating with a sewer shall insert the beaded spigot end of such iron soil pipe, waste pipe, ventilating pipe, or trap into a socket of such stoneware or semi-vitrified ware pipe or drain making the joint with Portland cement; provided always that it shall be sufficient if he shall connect the iron soil pipe, waste pipe, ventilating pipe, or trap with the stoneware or semi-vitrified ware pipe or drain in an equally suitable and efficient manner.

Any person who shall connect a stoneware or semi-vitrified ware trap or pipe, with an iron soil pipe, waste pipe, trap or drain communicating with a sewer shall insert such stoneware or semi-vitrified ware trap or pipe into a socket of such iron soil pipe, waste pipe, trap or drain making the joint with Portland cement; provided always that it shall be sufficient if he shall connect the stoneware or semi-vitrified ware trap or pipe with the iron soil pipe, waste pipe or drain in an equally suitable and efficient manner.

Any person who shall construct any water-closet, the soil pipe of which shall communicate with any sewer and shall be in connection with any other water-closet, shall cause the trap of every such water-closet to be ventilated into the open air at a point as high as the top of the soil pipe or into the soil pipe at a point above the highest water-closet connected with such soil pipe and so that the ventilating pipe shall have in all parts an internal diameter of not less than 2 inches and shall be connected with the arm of the soil pipe or trap at a point not less than 3 and not more than 12 inches from the highest part of the trap and on that side of the water seal which is nearest to the soil pipe. He shall cause the joint between the ventilating pipe and the arm of the soil pipe or the trap to be made in the direction of the flow.

He shall construct such ventilating pipe in drawn lead or heavy cast iron. Provided that in any case where it shall be necessary to construct such ventilating pipe within a building he shall construct such ventilating pipe in drawn lead.

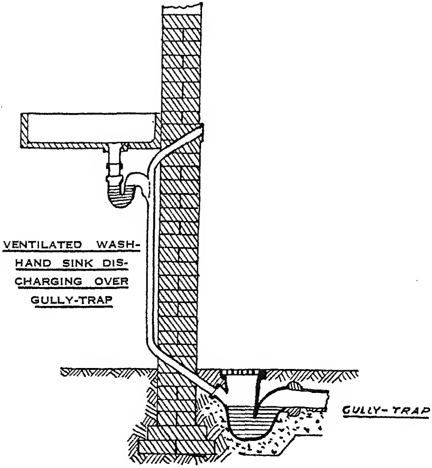
He shall construct such ventilating pipe, whether inside or outside a building so that if the pipe be of lead its weight shall not be less than 45 lbs. per 12 feet length and if the pipe be of iron, its thickness shall not be less than 3/16th inch and its weight not less than 25 lbs. per 6 ft. length.

He shall in all cases cause the joints in and the connections to such ventilating pipe to be made in the same manner as if such ventilating pipe were a soil pipe.

A person who shall erect a new building and shall construct in connection with such building a slop-sink or urinal constructed or adapted to be used for receiving any solid or liquid excremental filth for conveyance to any sewer, shall construct or fix immediately beneath such slop-sink or urinal an efficient syphon trap, so constructed as to be capable of maintaining a sufficient water seal between such slop-sink or urinal and any drain, soil pipe or waste pipe in connection therewith. He shall not construct or fix in or in connection with such slop-sink or urinal any trap of the kind known as a bell-trap, a dip-trap or a D-trap.

He shall, as regards the ventilation of the trap of such slop-sink or urinal and the construction of the waste pipe of such slop-sink, or urinal, comply with all the requirements of the preceding by-laws which are applicable

to the ventilation of the trap of a water-closet and the construction of a soil pipe, always provided that the internal diameter of the waste pipe of any such slop-sink or urinal shall not be less than 3 inches and where the internal diameter of such waste pipe is 3 inches, the weight of such pipe for every 10 feet of length, shall, if such waste pipe be constructed of lead, be not less than 60 lbs. and if such waste pipe be constructed of cast iron, the weight of such pipe of every 6 feet of length shall be not less than 40 lbs.

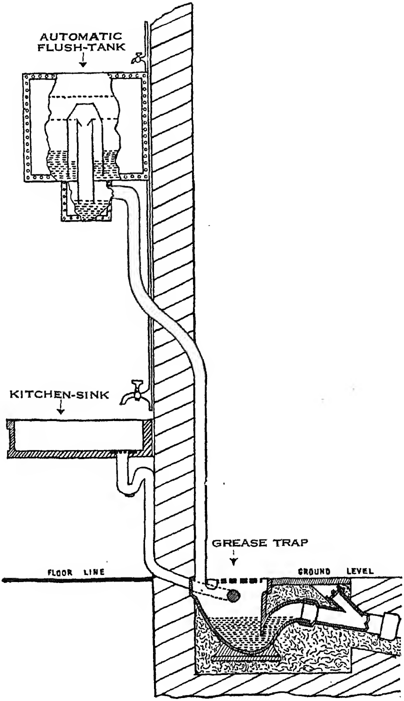


The owner of any building shall, as respects such building, at all times maintain in a proper state of repairs all pipes, drains, and other means of communicating with sewers and the traps and apparatus connected therewith.

A person who shall newly fit or fix any apparatus in connection with any existing water-closet shall, as regards such apparatus and its connection with any soil pipe or drain, comply with such of the requirements of the foregoing by-laws as would be applicable to the apparatus so fitted or fixed if the water-closet were being newly constructed.

There are special by-laws also in reference to outside closets, basement closets, earth closets, privies and cesspools.

Every person who shall intend to construct any water-closet, earth closet, or privy, or to fit or fix in or in connection with any water-closet



earth closet or privy, any apparatus or any trap or soil pipe, shall, before executing any such works, give notice in writing to the clerk of the Sanitary Authority.

The occupier of any premises shall cause every water-closet belonging to such premises to be thoroughly cleansed from time to time as often as may be necessary for the purpose of keeping such water-closet in a cleanly condition.

Provided that where two or more lodgers in a lodging-house are entitled to the use in common of any water-closet, the landlord shall cause such water-closet to be cleansed as aforesaid: one closet to every twelve persons.

The owner of any premises shall maintain in proper condition of repair every water-closet and the proper accessories thereof belonging to such premises.

PENALTIES.

Every person who shall offend against any of the foregoing by-laws shall be liable for every such offence to a penalty of Two pounds, and in the case of a continuing offence to a further penalty of Forty shillings for each day after written notice of the offence.

BY-LAWS OF THE BOMBAY MUNICIPALITY.

Construction of Water-closets and Privies.

[Clause (*a*), Section 461].

1. *Water-closet.*—Every person who shall construct a water-closet for use in connection with a dwelling-house shall comply with the following regulations:—

(*a*) He shall cause such water-closet to be separated from any room intended to be used for human habitation, by a *dead* wall which shall be lined *internally to a height of six feet* with a smooth, impervious, non-absorbent coating of neat Portland cement not less than half an inch in thickness, or of glass, glazed tiles or polished marble.

(*b*) He shall make, in one at least of the walls of such water-closet a window of not less than 3 square feet superficial area opening upon an external open space.

(*c*) He shall cause the entrance to such water-closet to be through a lobby or *bath-room having at least one window*, or through a gallery which is entirely open to the outer air on one side.

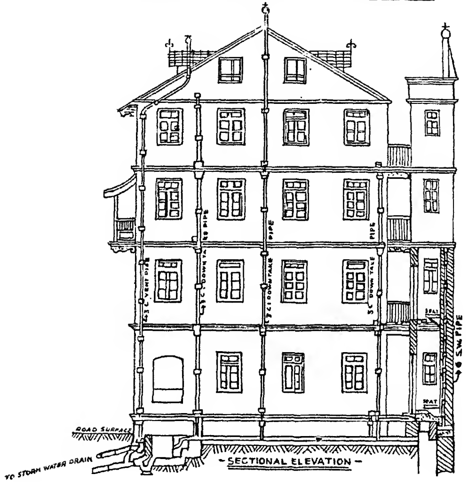
(*d*) He shall not construct any portion of such water-closet so as to be within a distance of 3 feet from the boundary of the owner's premises, provided that this rule shall not operate to prevent a water-closet being constructed to abut on a street or service passage or open space intended to be permanently reserved as such.

2. *Privies.*—Every person who shall construct a privy shall comply with the following regulations:—

(*a*) He shall provide on each side of such privy, except the entrance side, an open space at least 3 feet in width within the limits of the owner's premises and open to the sky.

(b) He shall cause any entrance, gallery or communicating bridge to be at least 3 feet in width and open to the external air on both its sides and to be shut off from any portion of any dwelling-house by a closely fitting door.

—TYPE OF HOUSE-CONNECTIONS WITH AN OPEN DRAIN—



(c) He shall make, in one at least of the walls of such privy, a window of not less than 3 square feet superficial area, opening upon an external open space.

(d) He shall cause the walls of such privy to be lined *internally* with a smooth, impervious, non-absorbent coating of neat Portland cement not less than half an inch in thickness or of glass, glazed tiles or polished marble to a height of not less than five feet above the floor of such privy.

WATER-CLOSETS.

In the case of water-closets, native pattern soil pans of design approved by the Drainage Engineer may be provided and shall be properly

laid and bedded in cement concrete at the required level and connected by means of porcelain traps and 4″ stoneware pipe and bends with an inspection chamber or soil pipe as the case may be. European pattern soil pans of design approved by the Drainage Engineer may be provided and shall be fixed in position with a teakwood moveable or hinged seat. (See sketch.)

The junction between a closet and branch, if the latter is of lead, shall be effectively made by a brass ferrule, soldered with a wiped joint to the lead pipe, and the joint between the porcelain trap and the brass ferrule made in cement, boiled oil and spun yarn or soldered to porcelain. (See sketch.) Lead soil pipes when used shall be 4″ in diameter and 3/16″ in thickness and shall weigh not less than 6 lbs. per square foot.

All soil pipes shall be 4″ in diameter and of cast-iron not less than 3/16″ in thickness. The connection between the soil pipe and the water-closet trap shall be by means of a pipe fitted with a screw cap external to the wall for cleaning purposes. (See sketch.) The soil pipes shall be not less than 44 lbs. per 6″ length.

Every soil pipe shall discharge into the 6″ stoneware pipe drain by means of a 4″ stoneware bend into a chamber fitted with a cast-iron cover. (See sketch.)

In every case where there is a tier of water-closets one above another, a 2½″ anti-siphon pipe shall be taken from each water trap except that of the highest water-closet and carried up above the roof and to such height as is prescribed in Rule 11. (See sketch.)

A three-gallons automatic or pull off flushing cistern of a pattern approved by the Drainage Engineer shall be securely fixed to the wall at least 5 feet above the seat and shall be connected by means of a 1¼″ lead pipe to the closet (See sketch), the flush pipes being connected to flushing cisterns by means of brass unions and plumber's wiped joints, and to W.C. pans with red lead, boiled oil and cement provided that the Drainage Engineer may permit the galvanized iron pipes in place of lead pipes where he thinks proper.

All such flushing cisterns shall be supplied by means of an efficient water supply from a reservoir tank placed in a suitable position and height. The capacity of this reservoir tank shall not be less than 90 gallons for each seat.

RULES FOR HOUSE AND STABLE DRAINAGE.

OPEN DRAIN.

1. In no instance shall a drain interior to a building for the conveyance of the house-sullage to the street-sewer be an open drain.

2. Open drains shall be constructed according to the plans in the office of the Deputy Executive Engineer, Drainage Department. The Drainage Engineer shall have the option of allowing the open drain to be in the centre of a house-gully and without side walls. The bottom part or invert shall be lined with a 4″ half round stone-ware channel, the remaining part of the drain being plastered with at least a 1″ coating of cement and sand (1 to 1) trowelled to a smooth surface or with any other impervious material.

3. At the end of the open drain a silt chamber 2′ long by 7″ wide, and 12″ deeper than bed of the drain shall be constructed with a vertical cast iron grating 1′-6″ from the open drain the full size of the silt chamber. This shall discharge into a gully trap connected to an inspection chamber (See sketch.)

4. The inspection chamber shall be not less than 3′ long by 18″ wide constructed of brick work laid on cement concrete and be internally plastered with a 1″ coat of cement and sand (1 to 1). In the chamber a stoneware channel with a half round S.W. invert shall be formed of the width and full depth of the pipe drain. The walls shall be brought up to the surface of the ground and covered with a cast iron air-tight cover and frame.

5. The cover of an inspection chamber shall be of cast iron air-tight and fitted with a lip into a grooved frame. The cover and frame of an inspection chamber subject to wheel traffic shall be of cast-iron of heavy pattern. At the connection between the 6″ pipe drain laid in the street by and at the expense of the Municipality and the drain constructed by the owner, an inspection chamber shall be provided fitted with a 6″ stoneware intercepting sewer trap of approved pattern having a water seal not less than 2″ and a 3″ ventilating shaft in accordance with Rule 11. In all other respects the inspection chamber shall be constructed in accordance with Rule 4.

6. All down-take pipes shall be of cast iron, 3″ in diameter and not less than ⅛″ thick.

7. The connection between every nahani and the down-take pipe shall be by means of a 3″ stoneware or 3″ cast iron pipe, discharging into a cistern head. Nahani traps may be used, but, if directly connected to the waste water pipes, the latter shall be extended above the roof in accordance with Rule 11.

8. In the case of nahanis abutting on a street or road, the waste water pipes shall discharge into a stoneware gully-trap by means of a stoneware or cast iron bend. The gully-trap shall discharge into an inspection chamber fitted with a sewer trap as per Rule 5, to a private pipe drain. The waste water pipes or nahani connections shall be constructed in accordance with Rule 23 for pipe drains.

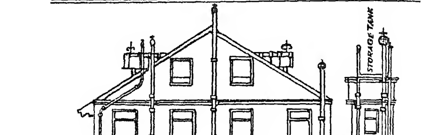
9. In the event of the plinth of a house being much higher than the bed of the open drain, nahanis on the ground floor shall discharge into the open drain by means of a 3″ discharge pipe brought down to such a level as to avoid a splash.

10. No water-closet or any arrangement by which night-soil is to be removed on the water carriage system shall, except with the written permission of the Municipal Commissioner, be allowed to be connected with an open drain.

11. Every vent pipe, anti-siphon pipe and waste water pipe shall, if not provided with cistern heads and discharging into an open drain, be protected at the top by a wire dome and shall be (*a*) carried at least 15′

higher than any sky-light or window situated within a distance of 40′ therefrom : (b) carried at least 5′ higher than the eave of the roof if affixed to a wall supporting the eave ; (c) erected or affixed so as to create the least practicable nuisance or inconvenience to the inhabitants of the neighbourhood.

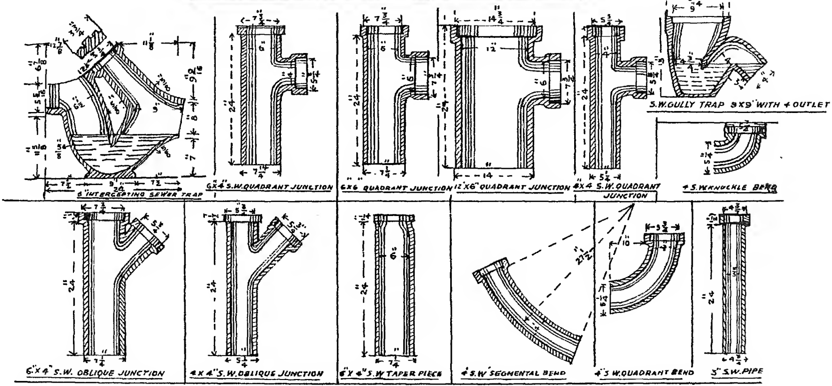
TYPE OF HOUSE CONNECTIONS WITH A 6″ PIPE DRAIN



12. The surface of all house-gullies not occupied by, or beyond what is occupied by, an open drain shall be paved with fine dressed blue-stone or Indian patent stone or other stone approved by the Commissioner. At the lower end of the gully, whether the open drain for sullage or sewage be in the centre or at the side, a jump-weir shall be formed as per full size plan to be seen in the offices of the Drainage Department, so that, while any ordinary flow of sewage will discharge into the connection with the inspection chamber, a rush of storm-water will jump over the opening and pass into the storm-water drain. (See sketch p. 181.)

General Rule.—All gully traps, when directed by the Drainage Engineer shall be covered with a hinged iron cover and frame of approved design.

—DIMENSIONED SKETCHES OF THE PIPES FITTINGS &c.—



PIPE DRAIN.

13. In all cases where house-owners desire to drain their premises by a pipe drain instead of an open drain, the drain shall be a 6″ stoneware pipe drain jointed in cement and laid at a gradient of 1 in 50 where practicable. When necessary, a flatter gradient may be allowed by the Drainage Engineer.

14. No drain shall be so constructed as to pass beneath any part of a building, except with the written permission of the Drainage Engineer and in conformity with such conditions as he may provide. In such case a heavy cast iron pipe drain (the joints to be run with molten lead and soundly caulked) should, in accordance with Section 240 of the Municipal Act, be laid under the building. Pipe drains may be of 4 inches diameter, only when allowed by the Drainage Engineer, 6″ C. I. drain pipe shall weigh 174 lbs. and 4″ C.I. drain pipes 90 lbs. per 6 ft. length.

15. At the connection between the 6″ pipe drain laid in the street by and at the expense of the Municipality and the pipe laid by the owner, an inspection chamber shall be constructed fitted with a 6″ stoneware intercepting sewer trap having a water seal of not less than 2″ and with a 3″ vent pipe with the open end of the pipe placed above the roof so as to comply with Sections 243 and 244 of the Municipal Act.

16. The cover of all inspection chambers shall be of cast iron, air-tight and fitted with a lip into a grooved frame. The cover and frame of an inspection chamber subject to wheel traffic shall be of cast iron of heavy pattern. In all other respects the inspection chamber shall be constructed in accordance with Rule 4.

17. Inspection chambers shall be so placed on any pipe drain that no portion thereof more than 75′ long shall be without an inspection chamber. An inspection chamber at the point of every change of direction in any drain shall be deemed indispensable.

18. Every 6″ gully-trap shall be connected with a 6″ pipe drain by means of 4″ stoneware branch pipe.

19. The head of every pipe drain shall be provided with a 3″ cast iron or galvanized iron vent pipe.

20. A nahani trap, approved by the Commissioner, shall be provided in every nahani except those specially provided for in Rule 23. (See sketch.)

21. All down-take pipes shall be of cast iron 3″ in diameter and shall weigh not less than 34 lbs. per 6′ length.

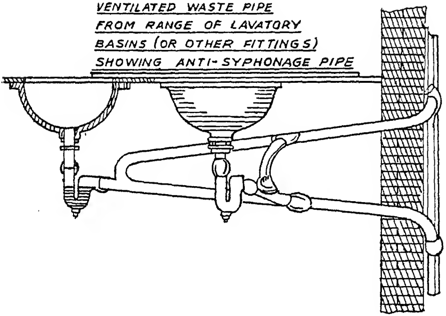
22. Every down-take pipe shall be carried up above the roof as a vent-pipe and be protected at the top by a wire dome as far as practicable, in accordance with the distances specified in Rule 11 as amended.

23. Every nahani on the ground floor shall discharge into a stoneware gully trap by means of a 3″ stoneware pipe and every down-take or waste water pipe shall be disconnected from the gully trap by means of a disconnection channel discharging into the gully-trap. (See sketch.)

23A. All lavatory basins, baths, etc., shall be trapped as near to the fittings as possible, the bath traps being not less than $1\frac{1}{2}''$ in diameter and the lavatory basin traps being not less than $1\frac{1}{4}''$ in diameter.

24. In the event of there being an open *chowk* in the house, the nahanis shall be constructed adjacent to the external wall of the *chowk* to allow of the down-take pipes being fixed to and carried up against external walls.

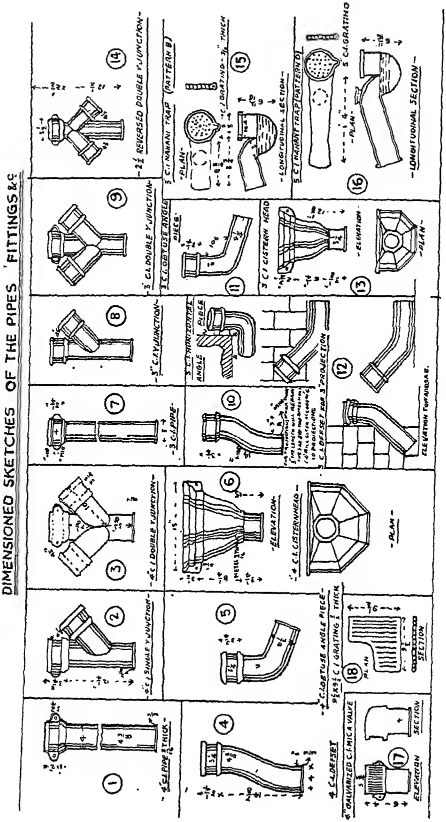
VENTILATED WASTE PIPE
FROM RANGE OF LAVATORY
BASINS (OR OTHER FITTINGS)
SHOWING ANTI-SYPHONAGE PIPE



GENERAL RULES FOR THE LAYING OF DRAINS, ERECTION OF ALL CAST-IRON PIPES AND THEIR FITTINGS AND FOR TESTING THE SAME.

25. The pipes must be of well-burnt glazed stoneware, uniform in thickness.

26. No pipe drain shall be less than 6″ in internal diameter, unless otherwise allowed by the Drainage Engineer, and must be laid at a gradient of 1 in 50 wherever practicable, unless otherwise allowed by the Drainage Engineer. Branch drains may be 4″ in diameter.



DIMENSIONED SKETCHES OF THE PIPES 'FITTINGS &c
4" C.I. PIPE 3/16 THICK
4" C.I. SINGLE Y JUNCTION
4" C.I. DOUBLE Y JUNCTION
3" C.I. PIPE
5" C.I. Y JUNCTION
3" C.I. DOUBLE Y JUNCTION
2½" REVERSED DOUBLE Y JUNCTION
4" C.I. OFFSET
4" C.I. CISTERN HEAD
ELEVATION
PLAN
3" C.I. OFFSET FOR 3" PROJECTION
3" C.I. HORIZONTAL ANGLE PIECE
3" C.I. OBTUSE ANGLE PIECE
3" C.I. CISTERN HEAD
ELEVATION TOWARDS A.B.
3" C.I. NAHANI TRAP (PATTERN B)
PLAN
C.I. GRATING 3/16" THICK
LONGITUDINAL SECTION
5" C.I. NAHANI TRAP (PATTERN D)
5" C.I. GRATING
4" C.I. OBTUSE ANGLE PIECE
9½ X 9½ C.I. GRATING ½ THICK
SECTION
4" GALVANIZED C.I. MICA VALVE
ELEVATION

27. The stoneware pipes shall be all laid and fitted dry previous to the jointing being commenced, such pipes being neatly cut as may need to be shortened in order to bring in the junctions in the exact position required. All the pipes shall be laid perfectly true both in line and gradient and they shall be laid on a 6″ concrete bed in the case of 'made ground,' or when in the opinion of the Drainage Engineer this course is necessary.

28. All the pipe joints shall be caulked with cemented or tarred gasket in one length for each joint and sufficiently long to entirely surround the spigot end of the pipe, the gasket to be driven as far as possible into the joint by means of a suitable instrument. After the pipes are thoroughly cleaned and moistened, neat Portland cement is to be forced into the joint until the whole space around the spigot, between it and the socket, is quite full, and a splayed fillet of neat cement is to be laid all round the joint.

29. Before filling in the trench, the joint of the pipe drains must be proved water-tight by filling the pipes with water to the level of 6″ above the top of the highest pipe in the stretch and heading the water up for the period of one hour or such further time as directed.

30. No stretch of pipe line shall under any circumstances be covered up until inspected and passed by the Superintending Plumber or the Drainage Inspector of the District as the case may be.

31. The inspection chambers on the pipe drains shall be constructed of brick work laid on cement concrete and be internally plastered with a 1″ coat of cement and sand (1 to 1). In the chamber a stoneware channel with a half round invert shall be formed of the width and full depth of the pipe drain. The walls shall be brought up to the surface of the ground and covered with a cast-iron air-tight cover and frame. The cover of an inspection chamber shall be of cast-iron air-tight and fitted with a lip into a grooved frame. The cover and frame of an inspection chamber subject to wheel traffic shall be of cast-iron of heavy pattern.

32. No joints shall be made in the walls without the sanction of the Drainage Engineer.

SOIL, WASTE AND VENT PIPES.

33. The socket joints between metal and metal when above ground shall be made completely air-tight with a mixture composed of Portland cement, boiled oil and chopped hemp and by a ring of hemp gasket.

34. The joints of pipes and shafts above ground after they are thoroughly set must be proved air-tight by smoke produced and applied as directed.

35. All the cast-iron appliances and fittings must be of approved pattern and coated by dipping in Dr. Angus Smith's solution before being used in the work.

36. In case of new buildings the drainage must be in accordance with the plan which has previously been approved by the Municipal Commissioner.

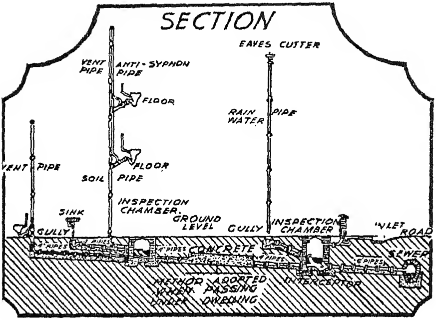


DIAGRAM OF HOUSE DRAINAGE ARRANGEMENTS.

HORSE-STABLES—PUBLIC OR PRIVATE.

37. The floor of every horse stable should be paved over the whole area with suitably dressed blue stone or other suitable material laid on a 6″ bed of good lime concrete. The paving shall be sloped at an inclination of at least 1 in 48 towards the channel hereinafter described.

38. Meeting the *muram* or paving and at right angles to the stalls shall be constructed a half round channel 12″ wide of suitably dressed blue stone or other suitable material.

39. The channel shall have a longitudinal slope of at least 1 in 100 to one point, or more as may be selected, and at each of such points a 6″ by 6″ stoneware gully trap fitted with horizontal and vertical cast-iron gratings shall be fixed. (See sketch.)

40. All the gully traps shall be connected by a 6″ stoneware pipe drain or drains with an inspection chamber constructed on a line of 6″ stoneware pipe drain connected with the street sewer. (See sketch.)

41. The construction of an inspection chamber, the laying of the pipe drain and connecting with the street sewer shall be in accordance with the rules laid down for pipe drains.

CATTLE STABLES.

42. The floor of every cattle stables shall be paved over the whole area with suitably dressed bluestone or other suitable material laid on a 6″ bed of good lime concrete. The paving shall be sloped at an inclination of at least 1 in 48 towards the channel hereinafter described.

43. Behind every range of stalls a half round channel 12″ wide shall be formed with a slope of at least 1 in 48 in every part down to a gully trap hereinafter described. (See sketch.)

44. The channel shall discharge into a catchpit through a glazed S. gully trap. The catchpit shall be 3′ by 4′ by 5′ deep. It shall be covered with a strong cast-iron cover fitted into a rebated frame. The catchpit shall be placed immediately at the point of discharge, or lowest point of the channel, and connected with the pipe drain within the premises by means of an inspection chamber built complete with a 6″ intercepting sewer trap. (See sketch.)

45. A horizontal and a vertical iron grating with bars not more than ½″ apart shall be fixed in the catchpit. (See sketch.)

46. The laying of the pipe drain, the construction of the inspection chamber and the connection with the street sewer shall be subject to the rules for pipe drains.

CESSPOOLS.

Drainage of premises not within 100 *feet of a Municipal drain or some place legally set apart for the discharge of drainage.*

47. As far as practicable, buildings of this description shall be drained by open drains in accordance with the rules laid down for such drains.

48. If practicable, the sullage from all nahanis shall be discharged among vegetation or used for gardening purposes, but if this is impossible, then the sullage shall discharge into a cesspool having a capacity of at least 50 c. ft.

49. The capacity of a cesspool shall be calculated below the bottom of the inlet drain.

50. The house-drain, if open, shall be connected with and shall discharge by means of a 6″ by 6″ stoneware gully trap into the cesspool. All cesspools shall be closely covered and fitted with a cast-iron air-tight frame and cover.

51. Every cesspool shall be ventilated by a cast-iron or galvanized iron pipe not less than 3″ in diameter.

52. The vent pipe shall be protected at the top by a wire dome and shall be (*a*) carried at least 15′ higher than any sky-light or windows situated within a distance of 40′ therefrom; (*b*) carried at least 5′ higher

than the eave of the roof, if affixed to a wall supporting the eave; and (c) erected or affixed so as to create the least practicable nuisance or inconvenience to the inhabitants of the neighbourhood.

53. There shall be a cesspool for the privies separate from that for the nahanis (if any) and it shall have a capacity of at least 3 c. ft. per every privy seat or slot, with a minimum of 25 c. ft.

54. Every cesspool must be placed in a position convenient for the access of Municipal carts.

55. Every cesspool shall be constructed of brickwork in cement laid on cement concrete and internally plastered with a 1″ coat of cement and sand (1 to 1). The walls shall be brought up to 6″ above the surface of the ground, and the cover mentioned in Rule 3 shall be placed upto them.

56. An arrangement must be made with the Municipal $\frac{\text{Superintending Plumber}}{\text{Inspector of Drains}}$ to attend at the premises to see the execution of the drainage work and the making of any connection that may be necessary with the Municipal drain.

57. No connection must be made with a Municipal drain nor must the same be exposed except in the presence of the $\frac{\text{Superintending Plumber}}{\text{Inspector.}}$

58. The whole of the work must be done under the supervision of the Municipal $\frac{\text{Superintending Plumber}}{\text{Inspector}}$ who may be seen daily between the hours of 7 and 8 A.M. at his office, in Mint Road, Fort; Charni Road, Girgaon; Bapty Road, Kamatipura; Babula Tank Road, and DeLisle Road.

59. The said $\frac{\text{Superintending Plumber}}{\text{Inspector}}$ will see that the principles adopted by the Municipality are carried out, but no such close supervision can be given by any Municipal Officer as to relieve the house owner and his plumber from the duty of taking due care in the execution of the work and providing good and sufficient materials and workmanship.

[*Note.*—A person erecting, re-building or occupying any building before arrangements necessary for the effectual drainage of such buildings are carried out in accordance with Municipal requirements will render himself liable to a penalty of Rs. 500 under Section 234 of the City of Bombay Municipal Act, 1888].

TESTING OF DRAINS AND SOIL-PIPES.

All new drains should be tested before being covered in and it may be necessary to test also old drains on a complaint of a nuisance. The following methods are usually tried.

The smoke test is applied by means of either a smoke rocket or a smoke machine. For the latter purpose, the Eclipse Smoke Generator or one or other of the smoke testing machines is employed.

The *Eclipse Smoke Generator* is most widely used and consists of three parts, a double action bellows opening into a cylinder of copper, in which the substance from which the smoke is to be generated is placed, and an out-let tube which is passed into the drain. The cylinder is placed in a tank of copper and is provided with a cover of the same metal which completely envelopes the cylinder when inverted over it. When the machine is to be used, the cover is removed, the tank surrounding the cylinder is filled with water, and the substance from which the smoke is to be obtained—either oily waste or some form of touch paper especially prepared so that it shall smoulder and in smouldering give off smoke in large quantities—is set alight and laid in the cylinder. The cover is then replaced and, dipping into the water in the tank, forms an air-tight joint and prevents the escape of smoke.

The out-let tube is then placed in the drain, an entrance having been found for it at some inspection eye in connection with a trap, or elsewhere along the course of the drain. By pumping air from the bellows into the cylinder, the oily waste etc., is set smouldering. The smoke generated is driven through the outlet pipe into the parts of the drainage system which are to be tested.

When the pumping has filled the cylinder full of smoke the connection between the cylinder and pumping bellows may be shut off. As soon as smoke is seen to issue from the top of the soil pipe or other natural outlet, further escape from these is prevented by plugging them with clay or damp cloth and the pumping is resumed. When it is concluded that a sufficient quantity of smoke has been driven into the drains, etc., pumping is stopped. This time if there is

no escape of smoke from the drains, etc., the cover of the cylinder will remain stationary and show no signs of sinking. If, however, there be any flaw in the system, the cover sinks, and a search must be made till the point where smoke is escaping is found.

In the *hydraulic test* the drains are subjected to the pressure of a head of water, the system being examined in sections. The first section may extend from the first water-closet to the first inspection eye, which may or may not be the point where the drain is disconnected from the sewer. At this point the drain is plugged by means of a rubber bag inflated with air or by means of a special apparatus like Addison's Patent Drain Stopper. The system is then filled with water from the first water-closet and, when full, the level of the water in the basin of the water-closet is noted. At the end of one or two hours, the level of the water is again taken, and if it has not varied the system is sound. If the water has subsided, the point where leakage has occurred must be sought for. The remaining sections are tested in the same way, the plug being inserted just beyond the last section tested.

For old drains this is a very severe test. Moreover, since the water pressure is greatest at the lowest point, the strain also will be greatest at this point. In applying this test to waste water pipes, the pipe will be plugged at the lower end and the water turned on at a sink tap till the pipe is full and a constant level of water obtained in the sink. The further procedure is as described above. Generally speaking for every additional foot of water in the pipe being tested, there results a $\frac{1}{2}$lb. of pressure to the square inch.

In the *pneumatic* or *the air-test*, air is forced by means of an air pump into the drain or soil pipe to be tested after the outlets are securely plugged. The pressure is indicated by an attached gauge and if the pressure obtained is maintained for five minutes, it shows that the system is air-tight. This test

is a very severe one as even a small pin hole opening will allow the escape of air and thus show a fall in pressure. A draw back of this test is that site of escape of the air and consequently the situation of the defect in the system cannot be detected, as the air is both colourless and odourless. This test therefore serves no practical purpose.

The Chemical test may be employed by pouring out a small quantity of a volatile oil like that of peppermint in a bucket of water and discharging its contents through a water-closet. The smell of peppermint oil along the system indicates the situation of the defect. Another method of performing the test is by using glass-capsules containing a composition of Phosphorus and Asafœtida. One or two such capsules are broken in a piece of blotting paper and thrown into the water-closet followed immediately by a flushing of the closet. As soon as the contents of the capsule come into contact with water, a slight explosion takes place and dense white fumes having the smell of Asafœtida are given off which are carried through the soil pipe and drain by the flush of water. The fumes escape through defects in the pipes, and the situation can be easily detected by the smell of Asafœtida.

In Kemp's apparatus used for the same purpose, the capsules are floated in the water of the trap and as soon as a string is pulled a spring is released which breaks open the capsule.

SEWERS.

The sewage is carried by means of sewers to the place of disposal by gravitation or pumping.

A sewerage system may be combined or separate.

The "combined system" is that by which all rain and storm-water, as well as sewage, is carried away by one set of sewers.

In the "separate system," there is provided a separate system of drains and sewers for rain water and sewage, the sewer only receiving that part of the rain which falls on open

spaces between houses and open drains which overflow into the sewer.

In India the "combined system" cannot be generally adopted because of the heavy rainfall, which is confined to a few months in the year.

The sewers would have to be made too large for the normal dry weather flow, and become defective and not self-cleansing in the dry weather season.

As it is, sewers may become surcharged in times of continuous rain of 6 to 10 inches in 24 hours, as frequently occurs in India.

DESIGNING AND CONSTRUCTION OF SEWERS.

The designing and construction of sewers is engineering work, but a knowledge of how such work should be done is valuable to a sanitary student as, in supervising the designing and construction, great care must be exercised in making the sewers water-tight, not only to prevent the sewage leaking out, but also to prevent the sub-soil water entering into the sewers and thus increasing the amount of sewage to be dealt with at the outfall. In many places, the quantity of sub-soil water is enormous especially in light, sandy, soils where the sewers are laid with difficulty, owing to the height of the sub-soil water and the joints becoming defective due to subsidence of the sewer. The amount of rainfall admitted into sewers has to be considered.

Before covering in a new pipe sewer, it should be carefully tested, so that leaky joints may be avoided.

VENTILATION OF SEWERS.

There are many agents at work affecting the ventilation of sewers :—The rate of decomposition of the sewage, temperature, pressure, wind, volume of the sewage, gradient and discharge of steam into the sewers.

The principle of ventilation is, by equalising the pressure inside and outside the sewer, to cause a free current of fresh

air to pass in and the foul air to pass out at the highest point well above the windows of the highest houses.

Sewers may be ventilated by open grids at the street level, well away from dwellings, by vent shafts attached to houses, or by building separate shafts at suitable points every 300 feet along the length of the sewer, every joint being made air-tight.

Open grids on the ground level are objectionable, and should be avoided if possible.

In tropical countries, the temperature of the air in the sewer is lower than the atmospheric air outside, while in England the reverse is the case. In Bombay, the mean temperature of the sewer air is 76° Fah., while the temperature outside is 79·5° Fah. At Cawnpore the temperature of the sewer air is 83° (mean air temperature).

The rate of decomposition of sewage varies with the pressure and temperature, and the gases of decomposition are therefore much more freely given off in tropical climates. The chief gases found in sewers, which are dangerous to life, are :—

> Carbon dioxide, CO_2 ; marsh gas, CH_4 ; nitrogen, N. ; ammonia, NH_3 ; sulphuretted hydrogen, $H_2 S$. and carburetted hydrogen, $C_2 H_4$; and great care should be exercised when examining sewers for cleansing purposes, to see that these gases are not present in any quantity.

Various methods have been adopted to purify the air of sewers : Charcoal trays, permanganate of potash (Reeves' process), gas lamps in the ventilating shafts, or street lamps used as vent shafts, fans and ejectors.

There is no hard and fast rule regarding the method of ventilating sewers ; much depends on the climate, the form and position of the sewer.

Messrs. Shone & Ault claim that efficient ventilation of drains and sewers, like the efficient ventilation of mines

can be secured only by abandoning the so-called natural system and substituting therefor adequately controlled and regulated mechanical means.

Delépine, reporting on the effects on health of the air of the High Street sewer (Manchester), states that—

"1. Taking the High Street sewer as a type of a fairly well constructed sewer, carrying moderately dilute domestic sewage of average composition, I have come to the conclusion that the air of such a sewer is free from noxious properties.

"2. This conclusion is not applicable to the air of sewers where, owing to the formation of deposits, or for some other reason, the air becomes loaded with an unnecessary amount of noxious gases which are not normally present under other conditions.

"3. It does not apply to sewers receiving certain kinds of trade effluents or waste products, poisonous in themselves, or liable to undergo changes or to produce compounds dangerous to health.

"4. This conclusion does not refer to the air escaping from foul drains or pipes, which air may be quite different from sewer air, or may contain particles of dried material not to be found in sewer air. The air escaping from such drains may be quite different from sewer air, and requires special study before any definite opinion can be offered as to the amount and kind of disease that may be attributed to it."

At a later stage in his report, Professor Delépine says:

"The passage of sewage bacteria into sewer air does not in itself prove that sewer air is necessarily a source of material danger. The experiments made show that in the air of an efficient sewer carrying ordinary domestic sewage, the number of sewage bacteria is very small; they also show that a number of human beings and animals exposed to a large amount of that air over considerable periods did not appear

to suffer from the exposure. Also that the discharge of a considerable amount of this sewer air through ventilating shafts had not caused any special outbreak of disease in the houses surrounding the ventilators.

" The results so far obtained show that in all probability the bad effects, which have at various times been attributed to sewer air, should have been considered as due to changes in the sewage which need not take place, or to admixture of noxious products which may be prevented."

Cleaning of Drains and Sewers.

1. The cleaning out of all-storm-water drains and channels, catchpits, and drain entrances should commence on the 1st of May in each year.

2. During the monsoon season, the Inspector should give special instructions to his Ward staff, regarding the keeping clear of refuse all gratings and openings carrying off storm-water, in order to prevent flooding so far as is possible ; and during periods of heavy rainfall, special men should be told off to attend to such places as from their low-level are most liable to become obstructed.

3. All covered drains and sewers should be opened periodically and examined with a view to ascertaining their state of cleanliness, and a memorandum of the result made in the drain-cleaning register. When a large drain or sewer is found to be in such a state as to require cleaning, a report should be made to the office.

4. In cleaning covered sewers into which it is necessary to send men, the following procedure should be strictly followed :—

(*a*) The manhole covers should be removed along the whole sewer at least two hours before any one is permitted to enter it.

(*b*) Ventilators should be inserted into the sewer at convenient points as soon as the manholes are

firmly upwards above the head, and kept above the head for 2 seconds, and then lowered to the sides against which they should be gently pressed ; the raising of the arms followed by the depression of them, in the manner described should be continued until breathing has been restored or until, in the opinion of a medical man, life has become extinct.

The object of these movements is to excite respiration. On the restoration of breathing, measures should be taken to restore the warmth of the body and promote circulation. Warm clothes should be ready, the body should be rubbed dry and wrapped in dry clothes.

When the patient is able to swallow, warm water or any spirit may be given.

10. On the report of an accident, medical aid should at once be called.

11. When it is believed that an accident has occurred in a sewer, the first measure obviously is to remove all human beings out of the sewer ; the number of persons in the sewer should at once be ascertained ; the assembling of persons around the manholes or entrances to the sewer should be prevented.

METHODS OF REMOVAL OF SEWAGE IN SEWERS.

It must be thoroughly understood that the water-carriage system, however valuable it is for large cities in India with an adequate water supply and proper facilities for the disposal of sewage, cannot be adopted in other places where the water supply is deficient.

The cities of Bombay, Calcutta and Madras are mostly sewered. Although in Bombay most of the excreta is discharged into the sewer, either by water-closets, or by pail depôts, there are still a few areas undrained The water-closet system is not universal throughout these cities. There are no other towns in India, besides these three mentioned,

where the water supply is sufficient for a proper system of sewerage and water-closet system to the houses; Cawnpore, and Delhi, Ahmedabad, Poona, Lucknow, Agra, and others are however progressing in this direction.

Under these circumstances, before advocating a sewage system, it will be necessary to enquire about :—

The population; the amount of water available per day per head of the population; the cost of the system and the connection of houses; the class of people who will use the water-closet; the geographical conformation of the area to be drained; the place and manner of disposal of the sewage and the degree of purification required; the rainfall.

A sewer must be self-cleansing to be efficient; self-cleansing means that the water supply per head of the population is sufficient to carry off the sewage and silt, at the rate of 3 feet per second in hot climates; in order that this result may be achieved, the fall or gradient must be sufficient, or an artificial method of pumping must be adopted.

In most of the large towns of India, some system of drainage has been adopted for the urine and sullage water, while the night-soil is removed by hand or carts either to hopper depôts or to trenching ground.

Sewers are made of glazed earthenware or iron pipes upto 18 inches and 2 feet, and in these sizes circular; when of larger dimensions, they may be of brick or cement and of an ovoid shape.

In laying a separate system, smaller sewers and man-holes may be laid with a great reduction of expense. A man-hole should be placed at every change of direction or where two sewers meet, and on straight lengths of sewers at every 100 yards.

The size of the sewers will depend on the amount of sewage and can be ascertained by the population and the water supply per head. In rural districts the amount of water

supply may be taken to be 10 to 25 gallons per head per day, in large urban and manufacturing districts 20 to 40 or more. A town of 30,000 people, without any important factories and having a water supply of 20 gallons per head, will have to dispose of 600,000 gallons of sewage per day and in addition a certain amount of rain. In English cities provision is made for 1 to 2 inches of rain per day, half of this passing off in six hours.

In India, where the rainfall is sometimes from 6 to 10 inches within 24 hours, a certain amount will find its way into the sewers, even if a separate system is provided for storm-water.

The Ministry of Health, England, allows storm-water exceeding six times the normal dry weather flow of sewage, to be passed into a water-course, which means that all sewage disposal works should be expected to treat up to six times the normal flow of sewage.

The sewer then should be capable of conveying half the average daily flow in six hours, or in the case of a town of 30,000 people, with a water supply of 20 gallons per head, 300,000 gallons in 6 hours=50,000 gallons per hour and 834 gallons per minute.

The sewers should be laid in straight lines, from man-hole to man-hole, and have even gradients sufficient to insure self-cleansing velocities.

In English towns, when the sewers are running three-fourths full, the velocity may be as low as 2 feet per second in very large sewers (over 24″), in the main sewers (12″—24″) not less than $2\frac{1}{2}$ feet per second, and in all the contributing smaller sewers (6″—9″) not less than 3 feet.

In India the sewage should be carried at a higher velocity, not less than 3 feet per second, in order to remove silt and convey the sewage away quickly.

The minimum depth at which sewers should be laid will depend upon whether it is necessary to drain the cellars of

houses ; as a rule, 10 feet from the surface of the road to the invert of the sewer is sufficient. Iron pipes laid on concrete may be used when the sewers are near the surface. When the sewer is 15 feet deep, earthenware pipes should be encased in concrete.

No sewer should be less than 1 foot in diameter. The size will depend on the amount of sewage and rainfall and gradient ; the internal sectional area can be thus calculated.

In large sewers a less gradient is required than in small sewers to induce the same velocity, but the volume of sewage will be the greater in the large sewer.

A sewer 10 feet in diameter having a fall of 2 feet per mile, a sewer 5 feet in diameter having a fall of 4 feet per mile, a sewer 2 feet in diameter having a fall of 10 feet per mile and a sewer, 1 foot in diameter having a fall of 20 feet per mile will have all the same velocity, but the volume of the sewage with the 10 feet must be 100 times that with the 5 feet sewer, and 25 times that with the 2 feet sewer, and 4 times the volume of sewage in the 1 foot sewer.

It frequently happens that in flat districts, it is impossible to so design a sewerage system that all the sewage can be conveyed to the point of outfall by gravitation. The only alternative is to pump or lift the sewage at suitably selected localities, and in cases where a number of such pumps or lifts are necessary or desirable, different systems have been devised whereby the sewage is raised from the sewers and discharged into the other sewers laid at a higher level.

SHONE SYSTEM.

One of these is the well-khown Shone system, in which compressed air is used as the power by which the sewage is lifted. At one or more places an ejector or, more usually, two ejectors are installed into which the sewage flows by gravitation.

An ejector consists of a spherically-ended container made either of cast or wrought-iron and placed in a brick-work chamber, or in a cast-iron tubing.

On the ejector becoming filled with sewage, the contents are forced by means of compressed air to a higher level through a rising main.

As soon as the ejector is empty, the compressed air escapes into the atmosphere through a high ventilating shaft and the ejector is ready for a fresh charge. The apparatus is automatic and requires only occasional inspection to ensure its regular and continuous working. An impression sometimes arises that, in the Shone system, the compressed air is in some way utilized to obtain a greater velocity in the sewers but this is not so.

The sewage gravitates to the ejectors at a velocity due to the gradients at which the sewers are laid and the ejector merely lifts the sewage to a higher level.

The efficiency of the system is low, but against that must be placed the fact that it is automatic in its action and that, unlike other pumping appliances, with the single exception of the Stereophagus pump, it will deal with unscreened sewage.

In India the system has now been working for many years both in Bombay and Karachi, and it has been adopted in many towns in England.

Experience has proved that in a tropical city such as Bombay, considerable difficulty is encountered during heavy rainfall in coping with the unavoidably increased flow of sewage in the sewers. Although separate storm-water drains exist, a large quantity of rain water reaches the sewer from open drains and paved spaces open to the sky. Ejectors cannot be installed of sufficient capacity to meet the heavy call that may thus be made upon them, with the result that they are overpowered during heavy storms and the sewers become surcharged. Unfortunately the

ejectors are incapable of much variation in speed, and it is not possible therefore to suddenly accelerate their rate of working as can be done with other types of pumping apparatus. On the whole, however, Shone's ejector is a useful and ingenious apparatus for lifting sewage but in districts subject to tropical rainfall, storm overflows from the sewers should be arranged for wherever practicable.

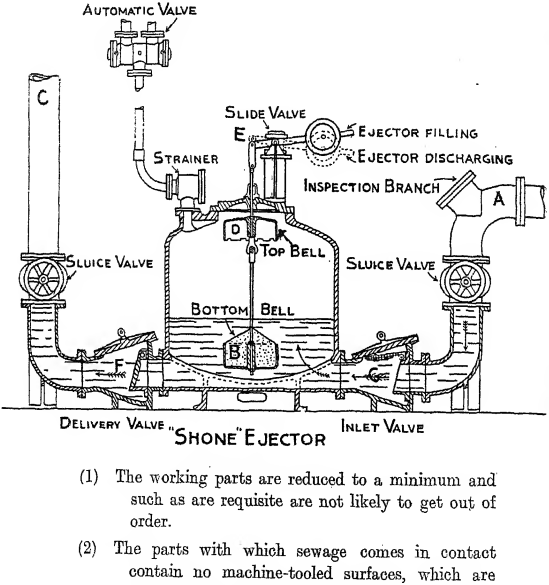
The working of an ejector is very simple, as will be seen by a reference to the figure on the following page. The sewage *enters by gravitation through the pipe A*, passes the flap G and enters the container. The sewage rises until it reaches the underside of the bell D ; the air within the bell is then enclosed and the sewage continuing to rise compresses the air until it can raise the bell D with the rod and cup B sufficiently to slide the valve E so as to admit air from the air main. As soon as the air is admitted, it is free to act on the surface of the sewage in the container. The pressure so applied closes the back-pressure valve G and forces the sewage past the flap valve F into the pipe C and thence into the sealed sewage main, the sewage being thus driven out of the ejector.

The sewage in the cup B cannot, however, escape, and its weight, when the sewage falls below the cup, is sufficient to lower the spindle with the bell, thereby re-sliding the valve E so as to close the mouth of the air-supply pipe, and open that of the exhaust pipe through which the compressed air in the ejector escapes into a shaft hereafter described. The outlet valve F then falls on to its seat owing to the weight of the sewage in the sealed sewage main and retains the liquid in that main, and the ejector commences to fill again. This process is repeated automatically so long as there is any sewage to flow into the ejector.

These ejectors are constructed by Messrs. Hughes and Lancaster. They are made of varying sizes, from 50-gallon capacity upwards. In Bombay there are several working from 100 to 1,200-gallon capacity each.

The compressed air for working the ejectors is produced in a central station, located in a position to suit all the ejectors, and is conveyed to them in cast-iron pipes laid in the streets at a depth of about three feet, where they are free from all danger of breakage from traffic and steam rollers.

The advantages of the ejectors as given by the Patentees may be summed up as follows :—



"SHONE" EJECTOR

(1) The working parts are reduced to a minimum and such as are requisite are not likely to get out of order.

(2) The parts with which sewage comes in contact contain no machine-tooled surfaces, which are unavoidable in pumps and get rapidly destroyed by the action of sewage, sludge and grit from the

road detritus, etc. In the ejectors there is nothing but the hard skin of the original castings, coated with Dr. Angus Smith's composition, upon which the sewage can produce no detrimental effect.

(3) The friction of a pump, piston and other working parts is avoided, the compressed air itself acting direct upon the fluid, without the intervention of any machinery, and forming an almost frictionless and perfect piston, past which there can be no slip or leakage.

(4) The cup-and-bell float arrangement is one that cannot possibly get out of order, as an ordinary rising and falling float would be likely to do.

(5) The only tooled parts are those in connection with the small automatic air-valve; this makes only one movement of two or three inches for each discharge of the container of from 50 to 1,200 gallons (according to the size of the ejector), and is in contact only with the compressed air and out of reach of the sewage.

(6) The sewage inlet and outlet valves are so arranged as to give free passage-way of the full area of the pipe, allowing free passage to all solids that the pipe itself can carry. No part of the container has any depression or traps wherein solid matter may collect.

(7) The outlet is from the bottom of the ejector, so that the whole of the sewage, including solids, sludge, grit and everything brought down the sewer, is discharged out of the ejector.

(8) For these reasons no screening or straining of the sewage is necessary, as is the case with pumps, and the great nuisance caused by the cleaning of pump gratings and sump wells is avoided.

(9) The sudden rush of the whole contents of the ejector when the discharge is into a main gravitating sewer, forms a most effective flush.

(10) The ejector forms an absolute severance of the sewers of each district from the main sewer.

The size of an ejector required for any district is determined by the estimated quantity of the sewage of the district, its capacity being equal to the number of gallons of sewage per minute at the time of maximum flow, which is one and a half times the average per minute of the total daily flow.

Each district should be provided with ejectors of the requisite size in duplicate, one being sufficient to cope with the ordinary work, the other being held in reserve. The two ejectors should be worked alternately, say every week or fortnight, to ensure that they are both kept in working order.

Cast-iron pipes required for air and sealed sewage mains need not be of the same thickness as those used for water works, as the pressure under which they work is comparatively light.

THE LIEURNER SYSTEM.

This is a pneumatic system and consists of collecting the night-soil and slop water only, direct from the water-closet through hermetically closed iron pipes, into chambers, by creating a partial vacuum in the chambers; the contents of the water-closet pass into an iron syphon tank, hermetically closed. From this tank the sewage is drawn, by the vacuum created by the pumping station, through iron pipes into the street sewer, and thence into iron chambers of the district reservoir, which is placed underground, in the centre of a district of about 30,000 people.

By a series of valves, these district reservoirs receive the contents of the street sewers, which ultimately pass into the central reservoir at the pumping station.

The advantages claimed are, that the sewers and house drains are air-tight and there can be no leakage and no foul air, that the pipes and sewers can be laid irrespective of gradient and no water is required, and that the whole process takes only a few minutes and can be repeated as often as necessary.

The sewage thus received at the central reservoir is manufactured into poudrette and sold as manure.

The system is at work in Trouville, Amsterdam, South Africa, and Stanstead, England, and is found to be satisfactory.

Each house connected has the ordinary sanitary fittings, water-closets, etc. No special fittings of any kind are required in the house. The sewage, however, instead of passing directly into the drain and thence into the sewer, as in the English system, is collected in an underground receptacle, a small iron tank, fitted with a syphon trap to cut off foul air from the premises and to prevent the admission of any foreign bodies, such as brushes or mops, which might tend to block the sewers. Each of these receptacles is ventilated by means of the soil pipe or a special ventilating shaft and communicates by means of an iron pipe, about 4 inches in diameter, with the street sewer. On each of the house drains there is a valve which can be used for disconnecting the house from the sewer, if ever the necessity arise. The street sewers pass directly to the receiving reservoir of the section. The mode of working is as follows: For six or twelve hours the sewage is allowed to collect in the house receptacles. A man then visits each district in succession and by opening certain valves places all the street sewers, with their connected houses, in direct communication with the district receiver, which is kept exhausted of air. Immediately the valves are opened, the air pressure outside forces the contents of all the house receptacles into the sewers and into the collecting reservoir. This is effected in a

few seconds. When all the street sewers are thus emptied, the valves are again closed, cutting them off from the receiver. The receiver is next placed in connection with the main sewer, when the whole of the contents is with extraordinary rapidity discharged therein and passes directly to a large tank at the sewage works. The district sewers are about 6 inches in diameter, and the main sewer is 8 inches to 12 inches in diameter. All are of iron with perfectly air-tight joints.

DISPOSAL OF SEWAGE: CHOICE OF METHOD.

Sewage generally may be said to consist of a mixture of saline matter in solution, and nitrogenous and carbonaceous organic matter in solution and suspension, together with a certain amount of grit and mineral matter.

Average composition of sewage in parts per 100,000. (Bombay).

Free Saline Ammonia	3.4
Albuminoid Ammonia	1.1
Oxygen absorbed in 4 hours at 27° C.	4.79
Chlorides	12.6
Total Solids	94.0
in suspension	24.0
in solution	70.0

The selection of a method of sewage disposal should depend primarily on local conditions.

The objects to be aimed at in its purification are the removal of the suspended matter and the oxidation of the remaining organic matter and ammonia.

There is a considerable amount of evidence to show that the oxidation of the organic matter, during its passage through filters or land, is chiefly a biological process, but as to the exact nature of the action which takes place very little is known.

It is practicable to purify the sewage of towns to any degree required, either by land treatment or by artificial filters, and there is no essential difference between the two processes, for in each case the purification, so far as it is not mechanical, is chiefly effected by means of micro-organisms.

The two main questions therefore to be considered in the case of a town proposing to adopt a system of sewage purification are, first, what degree of purification is required in the circumstances of that town and of the river or stream into which its liquid refuse is to be discharged ; and second, how the degree of purification required can, in the particular case, be most economically obtained.

The choice of a scheme must depend on a number of considerations, but the Sewage Commission state in their report that they know of no case where the admixture of trade refuse with sewage makes it impracticable to purify the sewage either upon land or by means of artificial processes, although in certain extreme cases special processes of preliminary treatment may be necessary.

The various methods of disposal of sewage are as follows :—

(1) Discharge into a river or the sea
(2) Subsidence, straining and precipitation
(3) Biological purification
  (*a*) Septic Tank
  (*b*) Contact-beds
  (*c*) Slate-beds
(4) Activated sludge process
(5) Purification on land
  (*a*) Intermittent downward filtration
  (*b*) Broad irrigation

(1) *Discharge into a river.*—The sewage of towns situated on the banks of rivers is usually discharged into the rivers,

but this should never be done without some preliminary treatment. The degree of purification of sewage required depends upon the relative volume of sewage to the volume of river water and where the volume of river water is large compared to the volume of sewage, the river water may be relied upon to complete the purification of sewage if it is previously treated in some way. In India, the towns situated on the banks of rivers usually discharge the crude sewage into the water. As the river water is used for drinking and bathing purposes without any purification, there is no doubt that pollution of water from unpurified sewage is the main cause of epidemics of Cholera and other intestinal diseases which break out now and then in such towns. Even large rivers are liable to run low during the hot season and, therefore, it is distinctly dangerous to discharge sewage into them without previous treatment.

Discharge into the sea.—When the town is situated near the sea, the readiest method is the discharge of the sewage into the sea, by means of iron sewers. In discharging thus a large bulk of sewage, great care is necessary to select a position, where the sewage will not be thrown back on the foreshore, as this will cause a most offensive and as time passes, an increasingly dangerous nuisance. A careful study of the tides should be made, and for this purpose float observations should be carried out at all states of the tide. These should be carefully considered, along with the prevailing wind and weather, in arriving at a decision. The greatest difficulty occurs during neap-tides, when sewage is likely to remain in the neighbourhood of the outfall for some hours. A sea-outfall should be taken away in the sea as far as possible from the shore so that the mouth of the outfall may be always under water even at the lowest tide. The liquid of the sewage rapidly diffuses into the sea water but the solid matter may persist for a considerable period without any change, especially as sea water delays oxidation of solid organic matter. The sewage having a lower specific gravity than

sea water floats on the surface exposed to the influence of tide and wind, and if carried down to the foreshore is liable to cause dangerous deposits.

In a sea-outfall, consideration should also be given to the question of local fisheries and oyster-beds. Fresh sewage discharged into the sea does little harm to the fish but putrefying sewage is distinctly dangerous and will destroy or drive it away. If oyster beds are situated near a sewage outfall the oysters may be infected with Typhoid and other organisms of intestinal diseases.

In large cities as in Bombay, where the gradients are not suitable there is difficulty in obtaining a continuous flow of sewage along the sewers. The sewage has, therefore, to be lifted up by the Shone System into the high level sewers, from where it can flow direct into the sea. During high tide, the outfall sewer gets water-logged unless its mouth is protected by a tidal flap-valve and high tide, therefore, interferes with the flow of sewage into the sea. To overcome this difficulty reservoir tanks may be constructed near the outfall to collect the sewage which flows in during high tide and it may then be discharged as soon as the tide recedes. In India, owing to the high atmospheric temperature, sewage would decompose rapidly and nuisance will be caused, therefore, by such accumulations of sewage into reservoir tanks. A better method, therefore, would be the construction of a pumping station at the outfall as is done in Bombay and the pumping of the sewage continuously into the sea at all states of the tide.

(2) SUBSIDENCE, STRAINING AND PRECIPITATION.

Subsidence or sedimentation is quiescent or continuous, etc., merely arresting the sewage and allowing the heavier particles to settle before passing on to land or over filters. The tank must be cleaned out frequently, at least once a week.

Straining.—Crude sewage is carried over beds of ashes or charcoal, through which its liquid portion percolates slowly. The solid matters collect at the top and cause clogging of the filters rapidly which require to be cleaned or renewed frequently. This method is, therefore, very expensive and is seldom practised.

Precipitation.—The process is now considered only one form of preliminary treatment on land or biological system, and in the case of some sewage containing trade-wastes is almost essential and, as a rule, aids in the subsidence of suspended matter and facilitates filtration.

The usual precipitants used are :—

Lime either by itself, as milk of lime 10 to 15 grains per gallon of sewage, or in conjunction with ferric sulphate 12 grains per gallon ; alumina ferric 5 to 15 grains per gallon of sewage; a mixture of alumina ferric, blood, charcoal and clay, (known as A.B.C.), 50 grains per gallon ; ferrozone 8 grains per gallon. The objections are the colour of the sewage, the supervision required in mixing, the cost and the disposal of the sludge.

Ferric sulphate and lime appear to give the best results. In trade-waste, where much fat is present, sulphuric acid is used, for recovering the fat, while in brewery towns lime is the precipitant.

The process of chemical precipitation is to a large extent mechanical, the precipitates produced by the chemicals used dragging down the suspended matter. A certain amount of chemical action takes place when lime is added, the lime combining with the carbonic acid and making an insoluble carbonate.

In the case of sewages which contain trade waste, and strong sewages from water-closets of towns, it is generally desirable to subject the sewage to some form of chemical treatment before attempting to oxidise the organic matter contained in it. In most cases careful chemical precipitation

materially aids the deposition of the suspended solids and facilitates subsequent filtration.

No general rule can be stated with regard to the capacity of precipitation tanks. With continuous flow, an eight hours' rate is usually sufficient to produce a fairly good tank liquor from a domestic sewage of average strength.

If sewage is allowed to remain quiescent in the tank, two hours' settlement would usually suffice.

TIME REQUIRED FOR SETTLEMENT IN TANKS.

Continuous flow with chemicals ..	8	hours in tank.
Continuous flow without chemicals. .	15	,, ,,
Quiescent with chemicals	2	,, ,,
Quiescent without chemicals ..	2	,, ,,
Septic tank without chemicals ..	24	,, ,,

In India it is found that 8 to 12 hours is sufficient for septic tanks.

Production of Sludge.—On the average, domestic sewage contains about 35 parts per 1,00,000 of suspended matter.

Sedimentation Tanks.—All tanks are sedimentation tanks, but it is convenient to limit the expression to tanks in which the sewage is allowed to settle without the aid of chemicals, and from which the sludge is frequently removed.

In some cases the tanks are allowed to stand full and the supernatant liquid is drawn off by a floating arm. In other cases, the sewage is allowed to flow through the tanks slowly but continuously.

Quiescent Sedimentation.—Two to three hours' quiescence is usually sufficient to produce a tank liquor fairly free from suspended solids, but owing to the fact that some sewage contains a larger proportion, than others, of solids that settle very slowly, no general rule can be laid down as to the necessary period of quiescence . With this form of treatment, the deposit in the tanks should be frequently removed.

Continuous Flow Sedimentation.—The amount of settlement effected does not depend upon the period of flow alone but upon a number of other factors. If the tank liquor is to be treated upon filters of fine materials, the period of flow should generally be from 10 to 15 hours. The tanks should be cleaned out at least once a week.

(3) BIOLOGICAL PURIFICATION OF SEWAGE.

In a sewage purification scheme, the essential points to be secured are :—(1) Disposal of solid matters in such a way that there would be no sludge problem ; (2) the resulting effluent should be clear, containing very little solid matter and free from odour, so that it may be safely discharged into a water-course ; and (3) absence of any nuisance from smell or otherwise in the neighbourhood of the sewage purification works.

The biological method of sewage purification helps to some extent to secure the above considerations. This system consists of encouraging the micro-organisms to act on sewage as it enters the purification works rather than check their action as is done by chemical treatment. The action takes place in two stages which differ from each other. In the first stage, the solids of sewage are broken up and carried into solution by one set of organisms, whilst oxidation of dissolved products and their conversion into harmless substances constitutes the second stage which is carried out by a second group of micro-organisms. The first group is called "Anaerobes" because they are active in the absence of light and air. The second group is called "Aerobes" *i.e.*, they require oxygen for their activity.

The actual changes which take place in sewage as a result of bacterial action are obscure and somewhat complex. In the first stage albuminous matters, cellulose and fats are broken up into soluble nitrogenous compounds, fatty acids, phenol derivatives, gases and ammonia. In the second stage, ammonia and carbon residues are changed into water,

carbon-dioxide, nitrites and nitrates. To enable the micro-organisms to perform their work under the best conditions possible and thus to secure these natural and biological changes in sewage, a number of installations have been devised. Though they differ from one another in matters of detail, they are all similar in principle.

As representing one in which purely anaerobic action takes place, and the one which is used in India in many places, we may consider Cameron's Septic Tank.

(a) SEPTIC TANKS.

The notion that the solid matter of sewage would be digested by passing the sewage through a sealed tank is by no means novel, but it does not appear to have had any extensive practical application until Mr. Cameron, who held the office of City Surveyor of Exeter, proposed the adoption of the "septic tank treatment" for that city. At that time it was claimed that the septic tank possessed the following among other advantages :—

That it solved the sludge difficulty, in as much as practically all the organic solid matter was digested in the tank.

That it destroyed any pathogenic organisms which might be in the sewers.

That sewage which had passed through a septic tank was more easily oxidised than sewage from which the solids had been allowed to settle, either with or without the aid of chemicals, in tanks which were frequently cleaned out.

As regards the first of these claims, it is now clearly established that, in practice, all the organic solids are not digested by septic tanks, and that the actual amount of digestion varies, to some extent, with the character of the sewage, the size of the tanks relative to the volume treated and the frequency of cleaning. The liquor issuing from septic tanks is bacteriologically almost as impure as the sewage entering the tanks.

Domestic sewage, which has been passed through a septic tank, is not more easily oxidised in its passage through filter than domestic sewage which has been subjected to chemical precipitation or simple sedimentation.

No definite rules can be laid down as to how long a septic tank should be run without cleaning. In the case of small sewage works (serving populations of, say, 100 to 10,000 persons), the tanks should generally be allowed to run, without cleaning, so long as the suspended matter in the tank liquor shows no signs of affecting the filters injuriously. For larger works, it would generally be advisable to run off small quantities of sludge at short intervals of time.

The rate of flow through a septic tank is a matter in which the needs of each place require special consideration, but at few places should the sewage be allowed to take longer than 24 or less than 12 hours to flow through the tank. In India 6 to 12 hours is sufficient. In no case should less than two tanks be provided, and they should be so arranged that, if necessary, one tank can be used alone.

As regards digestion of sludge and quality of the tank liquor, a closed tank possesses no advantages over an open tank because the scum at the top shuts off all light and air and allows anaerobic action to take place in the tank liquor. There is, however, less risk of nuisance if the tank and the feed channels to the filters are covered in.

The provision of a roof to the septic tank is a question of some interest from another point of view. If the roof of the tank makes no difference as regards the liquifaction of sewage and the quality of the tank liquor, one might dispense with the roof altogether as it would save the expense of its construction. It has to be remembered, however, that owing to the high atmospheric temperature in India, evaporation of water from the liquid contents of a tank without a roof would occur rapidly and the tank liquor may become concentrated to such an extent as to hinder bacterial action in the

tank. Besides, owing to the rainy season being confined to certain months in the year, heavy downpours of rain occur often enough during the autumn. This will cause the tank to be flooded at such times, with the result that its contents will overflow into the surrounding regions, causing thereby a nuisance to the neighbourhood. Lastly, things dropped in accidentally like stones or pieces of bricks are likely to break up the scum layer. For these reasons, a roof to the septic tank in the tropics is an absolute necessity.

During septic action in the tank, gases are given off which must be allowed to escape by openings in the roof. If this is not done, purification work almost ceases. The gases are not offensive but are highly inflammable. The mixture of gases consists of Methane, Hydrogen, Carbon dioxide and Nitrogen. They may be led away from the tank by proper arrangements and utilised for the purpose of lighting or working a gas-engine.

The effluent from the septic tank resembles dirty water in appearance and has little offensive smell. It is carried on either to aeration beds or percolating filters (see p. 224).

By passing septic tank liquor through tanks of a size sufficient to hold about one-quarter of the day's flow, with the addition of from 2 to 3 grains of lime per gallon to the liquor, the suspended solids in the liquor are materially reduced, the offensive character of the liquor is largely destroyed, and a considerably larger quantity of the liquor can be treated per cube yard of filter.

(b) CONTACT BEDS.

Our knowledge of the action of a contact bed is very incomplete, and little is known as to the manner in which the organic substances of sewage are broken down, during the first stages of fermentation, into carbon dioxide, ammonia, etc. The purifying agents seem to be not only bacteria but also worms, larvæ, insects, etc., and no opinion can be

offered as to the respective amount of work done by each set of agents; it probably differs to some extent according to the nature of the sewage. It has been observed that at some places large numbers of worms are present, while at others there are comparatively few.

Little is known of the kind of bacteria essential for purification, or as to their mode of action, and it cannot be stated whether they act chiefly during the period of contact or during the period of rest or aeration after the filter is emptied. There are, however, grounds for thinking that the resting period is the more important phase of the cycle.

The generally accepted theory, as regards nitrogenous matter, seems to be that the ammonia is extracted from the liquid during the period of contact and oxidised during the period of rest, and that the resulting nitrates and nitrites are diffused through the liquid during the subsequent filling. All the ammoniacal nitrogen, however, does not appear in the effluent in the oxidised state, for there is always loss of nitrogen, as nitrogen gas, during the process.

The withdrawal of suspended and colloidal matter from the sewage during the passage through the bed appears not to be a simple mechanical effect of the material, for a matured contact bed, not clogged, will withdraw more suspended matter from the sewage than another bed similar in all other respects but not matured.

CONSTRUCTION AND WORKING OF CONTACT BEDS.

In some cases contact beds have been made by simple excavation, but the evidence shows that in the majority of cases it is desirable that the beds should be constructed of building materials.

The beds are about four feet deep and are made up of broken stone, hard burnt clay or ballast, each of which offers a good surface for the development of bacteria.

Contact beds are worked in the following way. The bed is filled up and the sewage is allowed to remain in contact

for some time (hence contact-beds). Then they are emptied and kept empty for some hours for the purpose of aeration. Each bed is filled up thrice in 24 hours, it being estimated that 1 c. ft. of bacteria bed will daily deal with 1 c. ft. of sewage. The eight hour cycle is distributed as follows:—1 hour to fill, 2 hours to rest full, and one hour to empty. The remaining four hours to remain empty for aeration. This intermittent application of sewage ensures their proper working. If properly managed, they are capable of purifying sewage to the extent of one million gallons per acre of beds per day.

Single contact will, generally, only yield a good effluent where the sewage to be treated is weak, and then only after good preliminary treatment. For the purification of partially settled weak sewage, and of well settled as also of partially settled sewage of average strength, if the case is one in which a good effluent is required, double contact is necessary, while if a strong sewage has to be treated triple contact is necessary, unless the preliminary treatment is exceptionally good.

The contact bed may be upward contact and the liquor, after being in contact with the coarser material, is distributed by filtering trays or distributing gear over the percolating filter. The effluent is as a rule fit to pass into a river, but, if the river-water is used for drinking purposes, it would be necessary that the effluent be passed over land.

(c) Slate-Beds (Dibdin.)

These beds are constructed from the debris of the slate quarries. The slate slabs are arranged horizontally on suitable slate blocks leaving intervals of 2½ inches between adjacent layers, in tanks about 4 feet deep. The slate beds offer advantages over the contact beds previously described in as much as there is no progressive clogging and loss of capacity as occurs in the contact beds and there is no necessity for the frequent washing and renewal

of the contact-material. The beds can be washed out with the slates in situ. The solid matter left in the bed is much less in quantity and when removed, dries off inoffensively when exposed to the atmosphere.

The beds are filled from the top and emptied from the bottom. The filling and emptying each takes about 3 hours, the beds remaining full for 2 hours only. The effluent coming from these beds is clear and inodorous.

AERATION BEDS AND PERCOLATING FILTERS.

The effluent coming from the septic tank or contact beds is passed for final purification over filters in which it either remains in contact for some time (aeration beds) or through which it percolates (percolating filters).

Sewage filters may be divided into two broad classes: aeration beds and percolating or streaming filters.

Aeration beds are tanks filled with some filtering medium. In these tanks the sewage is held up before it is discharged. The bed, after it is emptied, is allowed to remain empty for some time before receiving the next filling. The length of time for which the sewage is allowed to stand in the bed is spoken of as the period of contact.

In *percolating filters*, the sewage is not held up but is allowed to percolate through continuously.

There can be no doubt that the organic matter in solution in the effluent can be oxidised by either type of filter, provided the filter is properly constructed and properly worked, but the question of the relative merits of the two types is one of some difficulty, as very few strictly comparative experiments on a large scale have been made.

Within ordinary limits, the depth of an aeration bed makes practically no difference to its efficiency per cubic yard. It would be generally inadvisable to construct beds of a greater depth than 6 feet or of a less depth than 2 feet 6 inches.

For practical purposes and assuming good distribution, the same purification will be obtained from a given quantity of coarse material, whether it is arranged in the form of a deep well or of a shallow percolating filter, if the volume of sewage liquor treated per cubic yard be the same in each case.

In nearly every case a greater rate of filtration per cubic yard can be adopted, if the material is arranged in the form of a percolating filter than if it is used in contact beds. In many cases the rate of filtration through percolating filters may be double or nearly double of what it could be with contact beds.

Filtering Material.—The materials in general use for aeration beds are clinker and coke; experience of other materials is not very great.

With percolating filters, however, many different materials have been used, and although the actual working of percolating filters is different from that of aeration beds, the results are, to a large extent, applicable. At York a quantitative experiment with septic tank liquor was made on a circular percolating filter, 7 feet 8 inches deep, and constructed in four segments, one of clinker, one of coke, one of slag and one of broken brick, the material in each case being broken and riddled as nearly as possible to the same size; the bulk of the clinker was, however, distinctly smaller than that of the other three materials. The results showed that the best effluent was obtained from the clinker segment, that the coke and slag segments gave very similar effluents, but not quite so good as the effluent from the clinker segment, and that the effluent from the broken brick segment was the lowest in the scale of purity. All the four effluents were of good quality.

With percolating filters there is apt to be nuisance from flies, especially with filters constructed of coarse filtering materials. In the warmer months of the year, such filters swarm with numbers of psychodidæ, which, though ap-

pearing to breed and develop in the filters, may usually be seen in large numbers on the walls of houses or buildings close to or on the works.

Size of Material.—The smaller the size of material used in an aeration bed, the greater is the internal surface area exposed, and consequently, the more intimate the contact of the liquid with the material, the greater the purification and the more efficient the arrest of the suspended and colloidal matter.

The efficiency of an aeration bed, however, depends very largely upon the admission of air to all parts of the filter during the time the bed is resting empty. Thorough and rapid drainage is therefore of the utmost importance.

With regard to percolating filters of fine material, if the liquid to be purified were absolutely free from suspended and colloidal solids, and if thorough aeration could be maintained, the statement just made for filters of coarse material might possibly hold good for filters of fine material also. In practice, however, these conditions can scarcely be maintained with large rates of flow, and the greatest efficiency can be got out of a given quantity of fine material by arranging it in the form of a shallow filter rather than of a deep filter. But it is difficult to make an exact quantitative statement as to the difference in efficiency of the two forms. The amount of sewage which can be purified per cubic yard of aeration bed or of percolating filter varies, within practical limits, nearly inversely as the strength of the liquor treated. This statement is based on the assumptions that the size of the material of which the filter is composed is, in each case, suitable to the character of the liquor treated, and that the material is arranged at the proper depth to secure maximum efficiency.

Percolating filters are better adapted to variations of flow than aeration beds. Effluents from percolating filters are usually much better aerated than effluents from aeration beds, and, apart from suspended solids, are of a more uniform

character. On emptying an aeration bed, the first flush is usually more impure than the average effluent from the bed. The risk of nuisance from smell is, however, greater with percolating filters than with aeration beds.

Where the liquor to be treated contains much suspended matter, it is usually advisable to construct filters, whether contact or percolating, with coarse filtering material. Where the preliminary treatment has effectively removed the greater part of the suspended matter, it is best to use fine material in the filters.

As a rule, special stand-by tanks (two or more) should be provided at the works and kept empty for the purpose of receiving the excess of storm-water, which cannot properly be passed through the ordinary tanks. As regards the amount which may be properly passed through the ordinary tanks in storm times, the rate of flow through these tanks may usually be increased without serious disadvantages to about three times the normal dry weather rate.

The points then to be considered, when advising on a biological system for disposal of sewage, are :—detritus chamber, septic tank, slate beds, contact beds, filter beds, effluents and outfall.

The sewage must be screened and passed into a septic tank, which may be covered or not. After remaining 8 to 24 hours according to climate, the supernatant liquor flows off and is distributed by mechanical distributors or sprinklers, or spread over a filter bed, or the sewage after being screened and admitted into a sedimentation tank passes to slate beds and filters and after sedimentation to contact beds and percolating filters, storm-water filters being provided for the increase due to rain.

(4) ACTIVATED SLUDGE PROCESS FOR THE PURIFICATION OF SEWAGE AND TRADE WASTE.

The purification of sewage and trade waste by a process, free from objectionable odour, has always been an ideal

and has apparently at last been rendered possible by the *activated sludge process*. The crude sewage is screened and thereafter is aerated by being agitated by mechanical agitators blowing air through it ; the process however consists not merely of aeration or agitation of the sewage but a combination of both, with the retention in the tank of the sludge, indigenous to the sewage, but activated by the process of aeration. In this process sewage organisms multiply rapidly in the sewage and their peculiar value is that in some way not yet definitely understood they induce the rapid settling of the sludge—the latter being of course in consequence changed with these organisms which are carried down along with the sludge ; the sludge is thereafter spoken of as "activated" or, in other words, "ripened," and portions of it can be used over and over again for the activation of fresh sewage.

Hitherto, with any sedimentation or septic tank process, retention in the tank induced anærobic conditions, a bad smelling effluent, and a worse sludge of so little fertilizing value, that the problem of sludge disposal often became more serious than that of purifying the liquid contents of the tank.

The activated sludge process not only yields a pure effluent but it also purifies the sludge, changes its character and converts it into a valuable asset.

Activated sludge is built up by aeration gradual at first the more or less purified liquid being drawn off and its place taken by more sewage, until about 25 per cent. of the tank contents consists of activated sludge. This proportion is then maintained and the surplus sludge is drawn off, for sale as it contains valuable fertilizing properties.

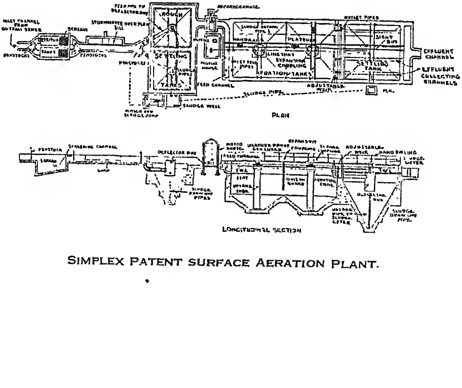
The details of the process as carried out differ according to the form of energy employed and the method of utilising it and the following account will illustrate the three principal methods which are being practised at present in different places.

In the first or the original, called the *Manchester System*, the form of energy employed is compressed air. The system may be described as consisting principally of a mixing tank, an aeration tank and a sedimentation tank. The mixing tank is so called because here the sewage entering into the plant is mixed up with the activated sludge passed back from the sedimentation tank through the central channel of the aeration tank. The aeration tank is divided into two aeration chambers by a central longitudinal channel, meant for reactivation of the return sludge from the sedimentation tank. In the aeration chamber are provided a number of baffle walls with openings at their bottom. The baffle walls prevent the rapid flow of sewage in the tank. Along the whole length of one side of the aeration chamber are fixed at right angle to the flow of sewage, a row of air-diffusers in the form of tiles each of which is connected, through an air-chest to a supply air-pipe. The diffuser tile is so made that it will pass 2 c. ft. of air per minute per square foot of the surface. The mixture of sewage and activated sludge enters from the small mixing chamber previously mentioned, and passes over the diffusers acquiring a spiral motion as a result of which the sewage and activated sludge are thoroughly agitated and aerated. The purified sewage then enters the sedimentation tank, pyramidal in shape where the sludge separates out by settlement. A part of this is transferred back to the central channel to be aerated again and reactivated and passed to the mixing tank, the rest being removed through the bottom. The effluent escapes over the sills, and may be discharged into a suitable outfall. The reactivated sludge is utilised for mixing with fresh sewage entering the plant.

In the second or the "*Sheffield System*", the agitation and aeration of sewage are carried out by mechanical means making use of the atmospheric air. The aeration tank is divided into 18 longitudinal channels by their divisional walls. Across the centre of the tank are arranged 18 paddle wheels driven by motors at a speed of about 15 revolutions per minute.

Each wheel is provided with 8 arms and alternate wheels rotate in opposite directions, agitating the surface of sewage so that fresh portions are brought into contact with the atmospheric air. The sedimentation tanks are pyramidal in shape. The process of purification in this plant resembles in principle, action and effect, the natural self-purification of river-water which takes place when polluting liquids are passed into it.

The third or the *Simplex System* consists of inverted cone-shaped tanks, in the centre of each of which an uptake tube is arranged which terminates about 6 inches above the bottom of the tank. The hopper shaped top of each tube contains a cone fitted with vanes and mounted on a vertical shaft. The cone revolves at a high speed drawing the mixture of sewage and sludge up the tube and throwing it outwards at the top, in the form of a fine spray. This brings the sewage into intimate contact with air. A continuous vertical circulation is thus maintained, the sewage and sludge rising



SIMPLEX PATENT SURFACE AERATION PLANT.

quickly up the tube and falling slowly through the body of the tank. As in the previous methods, the final separation of the activated sludge from the purified effluent is effected in deep sedimentation tanks.

In all the above methods, the detention of the purified sewage in the settling tank is determined by the strength of sewage and may vary from 6 hours for a weak domestic sewage to 12 to 16 hours for a strong sewage containing trade wastes.

The advantages claimed for the activated sludge process are :—

(1) It is hygienic, aerobic throughout, without smell, aerial nuisance or fly trouble.

(2) It dispenses with filters and secondary treatment.

(3) It reduces area and cost of work required.

(4) It involves no loss of fall and often saves pumping.

(5) It makes the sludge innocuous and a valuable fertiliser.

(6) Existing tanks can be utilised.

(7) Long outfall sewers are not necessary as works can be built near the town.

But there are certain disadvantages reported, *viz.*, the great bulkiness of the sludge rendering difficult the economical disposal of the sludge on account of its great volume. It is too early yet to state what is the future for this process. Already it has been tried successfully in England and the United States of America, and if the difficulties above-mentioned can be overcome, it may come into more general use.

(5) TREATMENT OF SEWAGE ON LAND.

It is generally desirable to remove from the sewage, by a preliminary process, a considerable portion of the grit

and suspended matter, before attempting to purify the sewage on land.

If a sufficient quantity of good land, to which sewage can gravitate, can be purchased at a moderate price, land treatment would usually be the cheapest method to adopt. In cases where only clay land is available, it would generally be cheaper and more satisfactory to provide artificial filters.

There are many cases where crude sewage has been passed over land, but the evidence shows that land treatment of crude sewage is liable to give rise to nuisance, by the accumulation of solids on the surface of the land. Moreover, in some cases these solids are apt to form an impervious layer and so impair the efficiency of the treatment.

There is *no essential distinction* between effluents from land and effluents from artificially constructed filters.

Effluents from those soils, which are particularly well adapted for the purification of sewage, contain only a very small quantity of unoxidised organic matter, and are usually of a higher class than effluents from artificial filters as at present constructed and used. Effluents from soils, which are not well adapted for the purification of sewage, may often be very impure.

VOLUME OF SEWAGE WHICH CAN BE TREATED ON LAND.

Generally speaking, the evidence points to a maximum rate of 30,000 gallons per acre, or 1,000 persons per acre, with the best land after preliminary treatment, although some put the rate as high as 60,000 gallons per acre, or 2,000 persons per acre, under similar conditions.

With unsuitable land, such as clay, not more than 3,000 gallons per acre can be efficiently treated, even after settlement of the sewage.

Table showing the approximate areas required with different soils.

—	Direct to Land.		After Precipitation of Mechanical Settlement.		After filtration on Bacteria Beds.	
	Ratio of population per Acre.	Acres per 1,000 persons.	Ratio of population per Acre.	Acres per 1,000 persons.	Ratio of population per Acre.	Acres per 1,000 persons.
Broad Irrigation.						
Gravel ..	100	10	500	2	1,000	1
Light Loam ..	100	10	500	2	750	$1\frac{1}{3}$
Heavy Loam ..	75	$13\frac{1}{3}$	200	5	400	$2\frac{1}{2}$
Chalk	..	..	..	..	..	..
Peat	Unsuitable.	Unsuitable.	Unsuitable.	Unsuitable.	Unsuitable.	Unsuitable.
Clay	50	20	100	10	300	$3\frac{1}{3}$
Intermittent Filtration.						
Gravel ..	150	$6\frac{2}{3}$	500	2	1,000	1
Light Loam ..	150	$6\frac{2}{3}$	500	2	1,000	1
Heavy Loam ..	75	$13\frac{1}{3}$	300	$3\frac{1}{3}$	500	2
Chalk	..	..	..	..	..	..
Peat	75	$13\frac{1}{3}$	200	5	400	$2\frac{1}{2}$
Clay	Unsuitable.	Unsuitable.	Unsuitable	Unsuitable.	Unsuitable.	Unsuitable.

Intermittent Downward Filtration.--After the sewage has been screened and the suspended matter removed in tanks, either by subsidence or precipitation by chemicals the sewage may be discharged on the land. *Intermittent downward filtration* is defined by the Metropolitan Sewage Commission as "the concentration, for short intervals, of sewage on suitable land, as small as will absorb and cleanse it, not excluding vegetation, but making the produce of secondary importance."

The action of the soil on sewage is both mechanical and biological. The suspended matter is removed and the organic

matter broken up by bacteria for nitrification. The nitrifying organisms feed on the organic matter of the sewage oxidising it.

The most suitable land is sandy, porous soil, but clay land can be broken up and made efficient by the addition of ashes. The surface of the land must be levelled, and the sub-soil under-drained with porous pipes, laid at a depth of 6 feet and 20 to 30 feet apart. The area should be set out in plots and each plot laid out on the ridge and furrow system. Each plot receives sewage for 6 hours with rest for the remaining 18 hours. The sewage flows down along the furrows while vegetables and grass may be grown on the ridges. The organic products of sewage are assimilated by the roots which thus purify it; whilst the leaves and stalks being above the sewage are not contaminated by the solid matter. One acre is required for 2,000 persons if the sewage is chemically precipitated, but if it is not, one acre for 1,000 should be allowed. The effluent is sufficiently pure to be discharged into a river or stream. In India less land would be required. Evaporation is faster and much sewage would be required to cover the land.

Broad Irrigation is defined as "the distribution of sewage over a large surface of ordinary agricultural land, having in view a maximum growth of vegetation (consistently with due purification) for the amount of sewage supplied."

The land should be a loamy soil, but sandy soil, gravel or clay can be so treated as to utilize sewage. The fall should be from the town to the site selected. Chalk soil is not desirable because of the fissures (swallow holes). After screening, the sewage should be brought to the land as fresh as possible and diverted to the different plots by means of carriers of earth or cement concrete, so that the sewage is properly applied.

One acre of land for 300 people is required by the Ministry of Health, England, but much less would be required if the

sewage is precipitated before being discharged on to the land. One acre for 1,000 persons is sufficient. Much depends on the character of the soil and sewage. Vegetables and grass grow luxuriantly, and in India, especially, sewage farms if properly managed are very profitable.

In tropical countries, in the presence of sewage farms or irrigation lands, the nuisance caused by mosquitoes has to be considered and in laying out such farms and in their management, this should receive every attention.

Wells in the Neighbourhood of Sewage Farms.—On general grounds, and quite apart from any scientific data, it would seem to be unsafe to sink any shallow wells in the neighbourhood of sewage farms, or to use water for domestic purposes from any such existing wells, unless the evidence as to the safety of the water were of a most convincing kind.

Deep wells sunk through an impermeable stratum are probably safe in the majority of instances, but wells not protected in this way and sunk through fissured strata cannot be relied on to yield a safe water supply, however deep they may be.

Chalk wells are, perhaps, the most dangerous in this respect, and a report by Dr. Copeman on an outbreak of Enteric Fever at Fulborn Asylum and a paper read at a meeting of the Epidemiological Society by Drs. Richards and Brinker serve to confirm this view in a striking manner. The latter mentioned that a culture of a special organism was poured into a "swallow hole" at a distance of about two miles from a well, and was recovered from the well water after $67\frac{1}{2}$ hours.

EFFECT OF TRADE EFFLUENTS ON SEWAGE PURIFICATION.

All the trade effluents interfere with or retard processes of purification to some extent, but the admixture of trade refuse does not make it impracticable to purify the sewage

upon land by means of artificial processes, although in certain extreme cases special processes of preliminary treatment may be necessary.

NUISANCE FROM SMELL.

All sewage works are liable at times to give off unpleasant smells; they should therefore be situated away from dwelling houses, wherever this is practicable.

The nuisance is apt to be considerably greater where the sewage contains brewery refuse in any quantity; but, on the other hand, the presence of some trade effluents, such as iron-salts or tarry matters, tends to render the process of purification less offensive. The extent of the risk of nuisance depends, however, not only on the character of the sewage but also on the method of treatment adopted.

COMBINED REFUSE AND SEWAGE DISPOSAL.

It can now be determined, in the light of what has been stated under Incinerators or Destructors (in Chapter II), whether it will not be possible to utilise the town refuse in acquiring power for dealing with the disposal of sewage.

In England the steam and electricity derived from the heat evolved in destroying refuse are used for many purposes including the pumping of sewage and the working of the gear for distributing it over the filters and making the concrete for building the filters. In some towns the electricity is available for tramways and pumping water.

TESTS FOR SEWAGE EFFLUENTS IN RELATION TO STANDARDS.

According to our present knowledge, an effluent can best be judged by ascertaining, first, the amount of suspended solids which it contains, and, secondly, the rate at which the effluent takes up oxygen from water.

The Sewage Commission in their eighth Report deal with the standards and tests for sewage and sewage effluents

discharging into rivers and streams and express their opinion that as a general standard—

(1) The effluent must be without fæcal odour or marked deposit.

(2) It must not contain as discharged, more than 3 parts per 100,000 of suspended matter.

(3) With its suspended matter included, it must not take up at 65° F. (18·3° C.) more than 2·0 parts per 100,000 of dissolved oxygen in five days.

(4) The amount of organic ammonia present should not exceed, ·1 part per 100,000.

(5) There should be no physical evidence of putrefaction when it is incubated for a week in a closed vessel at room temperature.

But the Commissioners maintain that the nature and volume of the recipient waters should also be taken into consideration and special standards, which may be higher or lower than the general standard, must be fixed, as the local circumstances require. In their opinion "if the dilution is very low it may be necessary to prescribe a specially stringent standard"—on the other hand, if the dilution is very great the standard may be relaxed or suspended altogether. They think (*a*) that if the dilution is not below 150 volumes and does not exceed 300, the dissolved oxygen absorption test be omitted and the standard for suspended solids fixed at 6 parts per 100,000. (*b*) But if the dilution is over 300 volumes and less than 500 volumes, the standard for suspended solids may further be relaxed to 15 parts per 100,000. (*c*) With a dilution over 500 volumes, all tests might be dispensed with and crude sewage discharged, subject to such conditions as to the provision of screens or detritus tanks as may appear necessary to the Central Authority.

PRACTICAL APPLICATION OF THE FOREGOING.

In very few cities in India at present, can a complete system of removal of sewage by water-carriage be adopted.

But in the majority, a partial system can be installed with great advantage.

Let us take, for example two cities in India : one with a population of about 50,000 the other with a population of about 120,000.

We are asked to advise on the best method of dealing with the sewage.

The cities are 1,000 miles apart in the Bombay Presidency. They are both situated close to rivers. One is peculiarly well situated as regards gradient, while the other is not so well favoured. The climatic and geological conditions differ. One has a scanty rainfall, is practically rainless, and has a high dry wind, while the other has an average of 29 inches per annum and during the rainy season is fairly humid.

The water supply in both cities is, or can be made sufficient—in one case it is from a gathering ground, in the other from a river.

Beyond the primitive system of sewage disposal and sanitary arrangements, they have nothing in common; the following description of the system in vogue with slight modification applies to both places.

At present the system of collection and disposal of night-soil and sullage water is most primitive.

The drainage system consists of innumerable open drains running either in the centre or sides of the streets and lanes into which drains from the houses run at right angles. These smaller drains passing along the streets and lanes are connected with main open drains, which discharge into private gardens, the owners of which pay the Municipality for the use of the sullage water. The drains are badly made and laid and are constantly blocked and become full of sullage water and have to be cleaned by hand labour.

The privy system consists for the most part of open spaces, sometimes covered, chiefly on the ground floor of a house or

in a blind lane but in some instances on the terraces. In many cases there are no seats or receptacles, the night-soil being deposited on the ground which is frequently unpaved. The excreta and urine and ablution water are also deposited on the bare ground: some is dried by the sun and some absorbed by the soil. Each privy has an open drain discharging into an open drain in the lane or street and is washed down by the *bhangi* after the night-soil is removed. The open drains convey urine and some night-soil and ablution water into the main drain in the street and discharge into the outfall drains. All the washings from the houses and lanes, therefore, are discharged indirectly into open drains.

There are many *mahals* or groups of houses in which privies are placed common to several houses. These privies are in close proximity to the windows of the houses, the entrance to which is by narrow lanes. In many of the lanes the sun is excluded. The night-soil and urine, remaining for hours, soak into the soil or are washed into the open drains or to some extent dried by the sun.

Private privies are cleaned by Municipal agency. All privies are not supplied with proper receptacles. Each *bhangi* has to clean fifty or more privies.

The privies generally abut on the open lane or street and passing along the lane, the water from the bathing places and privies on the ground floor or upper floors can be seen discharging into open street drains. The narrowness of the lanes is accentuated by the presence of the open drains which occupy a considerable part of the space meant for walking.

The Indian part of the town is thickly populated. The streets are narrow with long winding passages and the houses irregularly built, almost touching each other across the narrow lanes.

The European quarters and Cantonment and the bungalows are in open compounds. The sanitary arrangements are on the dry system and have private sweepers. The bath

and kitchen waste discharges into cess-pits or pails which are emptied and used in the garden, or put in a cess-pit cart which conveys it to the trenching ground. The Cantonment has latrines and urinals on various principles, on the dry and wet system, dotted about at convenient but frequently very unsightly and unsavoury positions. The night-soil drops into pails and the urine separates into buckets and the contents are conveyed by drain carts to trenches or incinerators.

In the cavalry barracks, the horse dung and litter have to be dealt with, and greater attention is necessary owing to the breeding of flies and mosquitoes.

As far as the European and Cantonment arrangements are concerned, as there is no system of sewage, the night-soil and waste are dealt with by the scavengering staff and can be properly supervised: much depending on the control and zeal of the authorities.

The European and Military population is about 3 per cent. of the whole.

Night-soil is removed to the north-east of the city where it is buried in trenches; each trench 200 feet long consists of seven partitions. It has been arranged to put the night-soil in each partition on each day of the week to facilitate early drying. Owing to the greater depth of trenches, drying takes a longer time. But the trenches have to be made deeper because of the limited space available. The dried night-soil in each trench is sold. For the removal of night-soil from the public latrines, *mahal* privies and private privies, there is a staff of *bhangis* with night-soil carts.

This system then is insanitary for the following reasons:—

The privy floors are connected to the open drains in the lanes.

The night-soil and urine and ablution water and bath water, if not removed, to some extent find their way into the open drains.

In these open drains, excreta, urine and sullage water remain close to living rooms and shops and form an obstacle to the traffic.

The night-soil and urine, if not removed, become a nuisance and danger to health. In many of the privies the floors are paved, and the *bhangi* after collecting the excreta, washes down the floor into the open drain. The urine and ablution water cannot be removed, but must either soak into the ground or discharge into the open drain.

The defects in this system are that human excreta, as well as other foul matter, are constantly being exposed in these drains. These drains overflow and discharge into the streets and lanes. They encroach on the already narrow lanes and the sides become broken and defective by the constant traffic. The lanes are so narrow that any influence the sun might have is prevented.

The ideal at which practical sanitation aims is the immediate removal and disposal of all excrementitious and polluted matter from the neighbouring dwellings without hand labour.

The present system is in every respect contrary to this.

The presence of human and animal excrement near the dwellings is a serious danger to health, apart from the obnoxious odour polluting the air in and around dwelling houses; there is a great danger of spread of Cholera, Enteric, Diarrhœa, Dysentry, Phthisis and infantile intestinal diseases. The food and water and milk are in danger of pollution either directly or indirectly by flies and vermin, while a damp, polluted soil constitutes an additional danger to health.

In the foregoing Chapter the data required for forming an opinion are given and may be re-capitulated.

The population, geological position, class of people and trade, facilities for draining and disposal; the cost of the

system and connection of the houses; the amount of water available per day per head of the population, the rateable value of the city and the annual income from all sources.

The question has been under consideration for 30 years in both places. Sanitary engineers and other experts have drawn up schemes; but lack of funds, want of pressure and passive resistance of the Municipality have deferred their application.

The Health Officer or the Civil Surgeon has reported on the necessity of doing something for improving the sanitary condition. The mortality is high, Plague, Cholera, Small-pox, Enteric and Diarrhœa are constant visitors, while Malaria is always present.

The water supply is from a gathering ground or river and is or can be made sufficient. The Health Officer has asked for and given good reasons for an increase in the staff; and improvement in the sanitary arrangement of the houses, urinals and public latrines and a system of drainage to carry off the sullage water and sewage; a septic tank installation with contact beds and percolating filters and effluent capable of being discharged into the river or on to a sewage farm.

The practical engineering and actual carrying out of the scheme is done by engineers and, although the financial aspect must be considered in advising on an improvement, it is assumed that the ways and means will be provided. Vested interests and weak administration interfere with and delay achievement—but this must be expected. It must not dishearten the sanitary official; he must continue to press and push forward schemes for the improvement of the district.

In some towns in India, schemes have been proposed, drawn up and considered for over 30 years before anything has been done.

It is a well accepted fact that the health of a community is improved by proper drainage of the soil and, although the

locality is for the greater part of the year rainless and has the natural advantages of a hot sun and a high wind, the constant pollution of the soil by the sullage water from the open drains constitutes a serious danger, which the laying of underground sewers will materially reduce.

The advantages of an underground system of drains properly laid with sufficient manholes, inspection chambers, flushing tanks and ventilators are: the immediate removal of all excrementitious and polluted matter without hand labour; the soil becomes drier, the atmosphere purer and the surroundings of the houses cleaner.

In Indian towns where the habits and customs of the people have to be considered, an underground system with water-closets connected and installed as in Western cities must, to a certain extent, be modified to suit these conditions, but it is an accepted fact that in Eastern towns, in spite of the habits of the people and their disinclination at first to adapt themselves to water-closets, a great, if gradual, improvement is noticed.

It is argued that the water-closet is misused and becomes choked with stones, sticks, earth, rags, &c., and the system gets out of order and that a certain class of people will not use water-closets and that *purdah* women would be prevented from using them unless placed inside the house and that there will be a danger of sewer air entering the house.

Compared with the advantages of a water-closet system, these objections are trivial and have all been put forward before in other places.

A properly constructed water-closet can, in every case, be kept cleaner than any form of privy; while the ablution water and urine and night-soil from these *nahanis* or bathing places can all be utilised for flushing the water-closet basins and drains. The sides of the receptacles can be kept clean and the walls of the building do not reek with the odour of stale urine and night-soil.

Practical experience shows that in public latrines frequented by all sorts of people, ignorant and wilfully careless, much trouble may be caused by the blocking of the drains by stones, sticks, rags, etc., and that a whole-time sweeper (halalkhor) must be engaged to flush and clean the basins; and the form of water-closet most suitable is the trough with automatic flush tank and inspection chambers. The blocking of the drains and water-closets with stones, sticks, rags, &c., must be guarded against by warning the people and by supervision and by provision of proper inspection chambers.

The supposed danger of sewer air entering the house is over-estimated. In a locality particularly where the water-closets are on the ground-floor, or detached from the dwelling, no such danger is to be apprehended.

A properly laid water-closet system affords no such danger as long as the water supply is sufficient and the traps and ventilation shafts, soil pipes and inspection chambers are kept in order. The hand labour of removal of night-soil is done away with and the sewage is carried away at once.

The advice, then, on the question before us is that, for the reasons given, a system of underground drainage properly constructed would be suitable to these two cities. Public latrines and urinals should be provided on the water-carriage system. Water-closet should be provided for groups of houses with automatic flushing tanks and the waste water from baths and washing places used for flushing the drains.

A certain number of pail depots should be provided to which night-soil can be conveyed from houses where water-closets cannot at once be installed.

The narrowness of the lanes and the congestion of the houses in the town proper naturally constitute a difficulty in dealing with the question of adopting any system of drainage, but there seems no immediate prospect of a scheme for widening these lanes. Looking at the present condition we are distinctly of opinion that the underground system

properly devised and carried out would be an improvement on the present arrangement.

On going over the different schemes, it will be seen that drains of varying dimensions can be brought up to within a few feet of most of the houses. Inspection chambers, manholes and flushing tanks should be provided and the connection of privies could then be made.

The Cost.—Although the question of cost may be outside the sphere of the ordinary sanitary student in England, unless he be surveyor or sanitary engineer or builder, this is a very important factor in India and one that delays improvements; every one interested in sanitation should have, therefore, some idea of the subject so as to guide him in advising on any particular scheme.

Much depends on the geographical position of the locality, the gradient, distance, depth of sewer, nature of soil.

In one case a scheme for draining a town may cost Rs. 10 per head of population, while in another it may be Rs. 20 or more. In England the cost (pre-war) of a complete sewage system and disposal of sewage was £1 per head of the population.

The cost of installing a water-closet will be from Rs. 750 to Rs. 1,000 including tanks, cisterns, connection, &c., complete.

The cost of a house connection varies with the width of the road and depth of sewer. In the case of a street 30 feet wide with a sewer 6 feet deep, each connection will cost about Rs. 70.

The expense, if borne by the landlord of small houses in ordinary towns in India, is very high compared with the value of his property; and the cost of installing water-closets or converting privies into water-closets and making house connections should be shared by the Municipality and the landlord either by financial aid, loans or by spreading the payment over a period of time; every inducement should

be offered. In many of the large towns in England, the alteration of the old privy midden or pail into water-closets has been carried out in this way.

As already pointed out, it will be some time before the open drainage system and the discharge of sullage on to the sullage ground and the trenching of night-soil can be done away with, but the tendency of sanitary engineering in India is towards that end. The general arrangement of houses in the thickly populated towns and the distance between bungalows in the wealthiest parts render this costly, but it can be done by degrees.

To briefly summarize :—

The water supply should be increased to 25 gallons per head per day as a minimum.

The out-fall on which the sewage is to be discharged should be acquired and properly laid out for a biological installation and effluent to discharge on the land.

The town proper should be drained and sewered.

Public latrines and urinals on the water-closet system should be provided and trough water-closets installed for groups of houses.

By-laws and regulations should be drawn up for the control of water-closets for private houses.

Financial assistance should be given to the landlord to provide water-closets and house connections.

Storm-water drains should be provided according to the rainfall and position of the locality, bearing in mind the prevention of mosquito-breeding places.

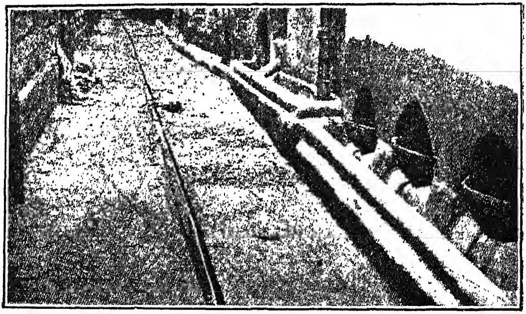
BOMBAY.

Bombay is the most sewered city in the East, that is to say, it has more sewers and more houses connected to the sewer and more water-closets.

At the same time there are a few houses with the old privy basket system; the basket is emptied twice daily and the contents discharged into the sewer at the pail depot. Between rows of houses a narrow sweeper's passage exists ranging from 1 foot to 5 feet wide. Houses of four and five stories abut on these passages, the living rooms opening on to them. The only ventilation many of the rooms have is from the filthy passages.

In Bombay, for conservancy purposes, 2 lbs. per head per day is the amount of night-soil estimated to be removed from the houses where privy receptacles are used, inclusive of ablution water and urine, much of the latter escaping into the open drains.

The halalkhor or sweeper or bhangi is an institution of tropical climates.



SWEEPER'S GULLY WITH BASKET PRIVIES AND OPEN DRAINS.

In sewered towns where water-closets are not general and where the houses are not all connected with the sewer, as in some parts of Bombay, the night-soil is collected by the halalkhor man or woman, from the privy receptacle,

outside or inside the house, situated chiefly in a passage between two houses; or it may be a commode in a bungalow or a public latrine in the street. The privy receptacle is made of basket work or iron and holds about 15 lbs. of excreta; it is placed on the ground-level in a trap or compartment.

The halalkhor basket holds roughly about 40 lbs. and when full is carried on the head some distance, varying from a few yards to a mile or more, and there deposited in the depot connected with the sewers. The number of trips made by the halalkhor varies with the distance he has to travel to the depot.

In streets, where the houses are close together, one man can collect and convey the contents of 30 privy receptacles; 3 receptacles go to a basket load. One receptacle may have to receive the excreta from 4 or 5 seats, according to the height and nature of the house, as the seats are placed one above the other in buildings of 4 and 5 storeys, and 1 seat is considered sufficient for 20 persons. In Bombay it is found that one man can make 8 trips of ½ a mile each way, between 6 and 9 a.m. and 3 and 4 p.m. carrying 40 lbs. of night-soil, the work being estimated thus:—

In a temperate climate an average day's work is calculated to be 300 foot-tons.

A man weighing 150 lbs. and walking 17 miles on a level road at 3 miles an hour does 300 foot-tons.

A halalkhor weighing 120 lbs. carrying 40 lbs. on his head, and making 8 trips in the morning and afternoon of ½ a mile each way per trip, would do about 150 foot-tons.

Let W=weight of man.

W1=weight carried.

D=the distance walked in feet.

C=co-efficient of traction $\frac{1}{20}$ at 3 miles an hour.

Then $$\frac{(W+W1) \times D}{2{,}240} \times C = \text{Foot tons of work done.}$$

One man can thus remove the contents of 30 receptacles making 8 trips of $\frac{1}{2}$ a mile per day.

In Bombay City, the sweepers or halalkhors attending the privies number about 750 men and women. They muster at 5-30 A.M., and then go round their respective beats collecting the night-soil from the privy receptacles into their baskets. After emptying each of the receptacles into the basket, the privy trap is washed out, if water is available or swept with a broom. The loaded basket is taken to the nearest pail-depot where the contents are discharged into a hopper connected with the sewer and the basket washed with water. The trips are repeated till the work in the beat is completed, each trip being marked in a depot-slip by the trip-marker. In the afternoon, the same practice is gone through. If the work of the sweepers is not supervised and checked they will scamp it either by making false trips or by depositing the night-soil in the open drains. That the system is one of the greatest evils in the City cannot be denied. It costs in wages alone Rs. 2,16,000 per annum without counting the cost of housing the sweepers.

In districts which are not sewered, the same procedure is gone through, the halalkhors emptying their baskets in a night-soil cart which removes the night-soil to the Depot.

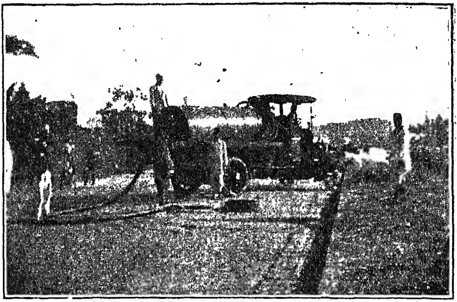
In addition, urine and ablution water are collected in a cess-pool and removed by a cess-pool cart or a vacuum cess-pool emptier to the Depot.

The capacity of a cess-pool cart is 32 cubic feet and it holds 200 gallons of cess-pool contents. On an average there are 25 privy cess-pools to each cart and the average number of trips made by a cart is three for the whole day. The average capacity of each cess-pool is 25 cubic feet, but this varies according to the district. Each cess-pool is usually emptied once in three days.

The vacuum cess-pool emptiers carry tanks holding 800 to 1,000 gallons and their introduction has been found to be both beneficial and economical.

On these lorries, a small combined air and vacuum pump is operated from the engine. The operation is expeditious and thorough. The emptier moves from cess-pool to cess-pool until the tank is filled and then proceeds to the Depot where the contents are discharged under air-pressure which operation is completed within a couple of minutes.

The average number of trips made by each emptier in a shift of 8 hours is six and about 100 cess-pools are allotted to each emptier.



THE CESSPOOL LORRY AT WORK.

The cleansing of house drains, and waste water pipes in Bombay.—The Health Department undertakes this work, instead of reporting choked drains to the Drainage Department. The work falls under the head of conservancy work, while at the same time it is an important part of the Sanitary Inspector's work as it is intimately connected with the sanitary arrangements of houses, a subject which the Sanitary Inspector is daily engaged on. All Sanitary Inspectors are expected to make it their duty to report on any defect in house drainage connections and assist the Conservancy Assistant Supervisors in respect to house drainage. The duties of the Conservancy Assistant Supervisors and Overseers are to supervise the cleansing of house drains and waste water pipes, and the opening of the same to remove chokes when necessary, and to serve notices on the landlords and recover expenses. Their duties do not cease here, as, in order to prevent daily chokes in drains, gully traps and waste water pipes,

constant supervision of all gully traps and drains is required and this includes the work of the mukadums, halalkhors, sweepers, begaris, plunger-men, and the throwing of kutchra from windows, and for this purpose they can call in the assistance of any of the Conservancy staff. The Overseers and mukadams especially, must be made to understand that they are to pay particular attention to the gullies and the way they are cleaned and to report chokes. The Conservancy Assistant Supervisor and Overseers will have frequent opportunities of noticing how the work of the halalkhors and sweepers is done, as in preventing chokes in drains much depends on the way the work is carried out.

The ordinary daily routine work is to inspect choked drains which have been reported and entered in the book kept at their office and start the work of removing chokes and to proceed on a tour of inspection in their division. If the block cannot be removed at once, notice must be served on the owners. Any drains found choked are to be noted and cleaned and the name of the mukadam of the particular section is to be taken down and entered in a book for reference, and inquiry made as to why the choke was not reported by him. When the house drain is free and the block occurs in the street connection, immediate notice is to be sent to the nearest Drainage Department office and confirmed afterwards by written intimation, copies of which should be kept in the usual way. All reports of choked or defective drains should be sent at once to the Assistant Supervisor's office, entered in a book and attended to daily by the Assistant Supervisor. The Supervisor must see this book daily, sign it and send it to the Head Supervisor.

Books of Notices under Sections 260 and 257 are supplied to the Head Supervisor and notice under Section 260 must be sent to the Commissioner for signature when required.

In Bombay the following general standard is laid down for the provision of water-closets or privies :—

In Dwelling Houses.—One seat for every 5 rooms occupied as separate tenements.

In Cinemas.—One seat for every 400 persons or less and one seat of urinal for every 200 persons or less.

In Theatres.—One seat for every 200 persons or less and one urinal for every 200 persons or less. One seat should be reserved for females.

In Schools.—See Chapter XIII (p. 1042).

In Factories.—(See p. 1197).

The requirements in London are :—

In Dwelling Houses.—One W. C. for 12 persons.

In Workshops.—One W. C. for 25 persons upto the first 100 and after that one for every 40. The workshop regulations take into account the fact that workers also use the W. C. in their homes.

Sewage Disposal in Bombay :—The greater part of the sewage of the city is discharged directly into the sea, while only a small part is subjected to biological and other methods of treatment. The sewage from the different parts flows in the large-sized concrete sewers towards the pumping station situated at Love Grove on the west coast of the island. The flow is mostly by gravitation, but in certain places where proper gradients are not possible owing to low-lying parts of the districts the sewage is lifted up by means of Shone System.

The sewage which drains into the pumping station is pumped into the sea and is carried into the sea water by two 6-ft. outfall sewers which are taken to a distance of 2 000 ft. from the shore. The pumping is continuous at all states of the tide and the number of pumps working depends upon the quantity of sewage draining into the pumping station.

Colaba, Mazagaon, Parel, Chinchpokli and Malabar Hill districts, as also the Agripada Estate are on the Shone System with 18 ejectors working in different parts in these districts. The motive power for these ejectors, viz., compressed air, is drawn from the central air-compression stations situated at suitable places.

The biological method practised for a part of the Malabar Hill district is the septic tank method. The sewage after being screened and the detritus allowed to settle, is passed into a closed tank, the capacity of which is enough to hold the 24 hours' flow. The effluent is passed on aeration beds of roadmetal, where contact is allowed for some hours. The purified effluent is discharged at low tides into the sea directly

which is close by and which is kept out from the beds by means of a high wall. The system works quite efficiently and there is no nuisance in the neighbourhood.

The sewage of the Leper Asylum at Matunga is also treated by the septic tank method and the effluent is utilised on land for cultivation of grass and vegetables.

A third method followed in Bombay is to treat the sewage with chlorine gas. The sewage of the Dadar Colony is treated in this manner and it is discharged subsequently into the Bandra Creek. It is doubtful whether this method is sound in principle. Chlorine may oxidise the gases of sewage, but the organic matter present will decompose later and produce nuisance at a certain distance from the point of discharge.

GLOSSARY OF TECHNICAL TERMS.

Aerobic.—"Living in contact with air." The term is applied to certain micro-organisms which live preferably in the presence of atmospheric oxygen and oxidize the ammonia in sewage into nitrites and nitrates. Aerobes are divided into facultative and obligate aerobes: the former can live in the absence of oxygen, the latter are unable to do so.

Anaerobic.—"Living without air." The term is applied to certain micro-organisms which live preferably without air, and reduce the organic matter in sewage, thus preparing it for treatment by ærobic bacteria.

Anti-Siphonage Pipe.—The term given to a small pipe which supplies air to siphons and traps, and prevents their being untrapped by a partial vacuum being formed through a sudden rush of water falling in a pipe to which the siphon or trap is connected.

Bacteria.—Bacteria is a generic term applied to a number of minute unicellular organisms belonging to the vegetable kingdom which multiply by fusion only. In this book the word bacteria is used generally to include micrococci and other members of this family.

Catch-Pit—A chamber built below the level of the invert of a sewer, in which the velocity of flow is reduced so as to collect such heavy deposit as may be in the sewage.

Conservancy System.—A system in which the fæces and urine are collected from privies and latrines by manual labour.

Combined System.—The name given to the system of sewerage in which the conduits are constructed for the double purpose of receiving both sewage and surface water.

Configuration.—The external aspect or contour of the land or district.

Datum—Some fact or quantity granted or known from which other facts or quantities are calculated, *e.g.*, a certain step at the Town Hall Bombay, is assumed to be 100 feet above an imaginary plane for the purpose of calculating other levels in the City.

Dhapa.—A slab of stone used for covering or spanning a masonry drain.

Disk-Valve.—A circular sliding iron door used for closing a pipe sewer.

Domestic Sewage.—The sewage derived from the habitations of men and beasts in contradistinction to that derived from factories.

Gasket.—A thin twisted or plaited rope put first into the joints or pipes to prevent the cementing materials from passing into the pipes.

Gradient.—The name given in sanitary engineering to the inclination or slope of a pipe or conduit : the vertical fall divided by the horizontal distance.

Grout—Cement mixed with water to the consistency of cream.

Inlet—The term applied to the higher or upper end of a pipe or conduit.

Intercepting Trap.—A trap or siphon placed on a house drain between the sewer and the house to intercept and prevent gas from the former passing up the drain or into the house.

Invert—The name given to the lowest portion of a sewer, pipe or drain.

Jump-weir.—A name given to an arrangement made at the street end of a house-gully, which permits of a small flow of sullage from the gully to fall into a trap in connection with the house drain, but allows of a greater flow of surface water to pass over and discharge into a drain set apart for the purpose.

Liquefying Tank—A tank in which the organic sewage matter is broken up or liquefied by bacteria.

Lamp-hole.—An inspection shaft over sewers down which a lamp may be lowered.

Manhole.—A masonry chamber, with a heavy cast-iron cover, built on a sewer or drain, through which it is possible to enter and have access to the sewer or drain for cleaning and inspection purposes.

Hydraulic Mean Depth.—This is equal to the sectional area of the current of fluid, divided by the wetted perimeter. In the case of circular sewers flowing full or half, it is a quarter of the diameter.

Outfall.—The point where sewers empty themselves.

Outlet.—The lowest end of a sewer or conduit or the end through which the sewage is discharged from a manhole, tank, etc.

Ovoid.—A term used to describe sewer built in the shape of an egg.

Oxidation.—A term used in sewage purification to denote the final change which takes place in destroying organic matter: the addition of oxygen to the effluent by the admission of air to the latter.

Pathogenic.—The name given to a class of organisms which, when introduced into the body, give rise to disease (Pathogenic=Disease-producing).

Prestock.—A gate usually made of iron and built into the body, so that it can be raised or lowered at will in controlling the discharge of sewage or water.

Plumb.—Vertical, or straight.

Precipitation.—The process by which a substance held in suspension in a liquid is made to separate from another or others and fall to the bottom.

Puddle.—Clay worked up by being mixed with water to a plastic or sticking condition.

Rubble.—Rough irregular stones used in coarse masonry or to fill up the interval between the facing coarses of masonry.

Scraper or Shield.—An appliance used in cleaning an ovoid sewer and made in the shape of the sewer with a portion of the bottom or the top cut off; when inserted in the sewer it heads up the sewage by contracting the area of the flow, which is consequently accelerated and facilitates cleaning by softening the deposit.

Seal.—The depth of contained water in a trap which prevents the free passage of air or gas through it.

Sectional System.—The name given to the system of sewerage in which a district is divided into sections, each of which has sewers gravitating to one point within it.

Separate System.—The name given to a system of sewerage, in which there are different conduits for storm-water and sewage.

Septic.—A term denoting the promotion of putrefaction.

Shored.—Propped or supported by timber.

Silt.—A term given to the deposit of solid matter found in sewers and drains.

Siphon.—A bent tube whose legs are of unequal length, used for drawing liquid out of a vessel, the shorter leg being inserted in the liquid and the larger hanging down outside; when the air is sucked from the tube the pressure of the atmosphere causes the liquid to rise in it and flow over.

Sludge.—Soft mud: the term applied to the deposit in biological tanks and filters.

Socket.—The opening at the end of a pipe generally enlarged into which is inserted the end of another pipe to make a joint. See "Spigot."

Spigot.—The end of a pipe which is inserted in to the enlarged end of another pipe to make a joint.

Sterilization.—By the expression "sterilization of any substance" is meant destruction or removal of all germs and their spores contained in or on such substance.

Sub-Soil.—The beds which lie below the surface soil.

Tidal Flap.—A door attached to a sewer at a manhole, by which the sewage may be retained in the sewer for flushing purposes (properly a gate used to exclude tidal water).

Trapped.—So formed as to hold a depth of water sufficient to prevent the free passage of air or gas.

Urban.—That part of a large city or town which has been fully built upon.

Water Gully.—A trapped receptacle through which the surface water from the road flows into an underground drain.

Water Tables.—Flat dressed stones fixed at the sides of a road over which the surface water from the road flows to the water gully or drain.

Wetted Perimeter.—The length (measured at right angles to the flow) of such parts of the sides and bottom of a conduit or channel as are in contact with the liquid.

Windsail.—A tube or funnel of canvas used to convey air into sewers or drains.

CHAPTER IV.

Water.

Water is a prime necessity of life. It assists in the building up of tissues, in the elimination of waste materials from the body and in regulating the temperature of the body under varying conditions of heat. It is composed of two elements, hydrogen and oxygen, in the proportion of two of the former by volume to one of the latter. Pure water should be clear, transparent, tasteless and odourless, and, when viewed in small quantities, perfectly colourless. When seen in bulk, however, it possesses a greenish blue colour. Practically speaking, water is incompressible, but the volume of any given weight varies largely with the temperature.

As a general rule, fluids at all temperatures between their freezing and boiling points expand when heated and contract when cooled, but water is an exception to this rule, as in freezing it expands about $\frac{1}{11}$th of its volume. Its maximum density is at 4° C. and if cooled below or heated above that temperature, it expands. The standard density of water is fixed at 4° C. in France, and at 60° F. in England.

The freezing point of water is 0° C., or 32° F., but if many salts are present, the freezing point is lowered and the boiling point raised, the water moreover having a higher density than ordinary water. In freezing it becomes purer, as it loses some of its saline constituents and air; ice water, therefore, is badly aerated and heavy. Water boils at 100° C. or 212° F. at the ordinary barometric pressure, but if the pressure be reduced, *e.g.*, by ascending a mountain, or by placing water under an air-tight globe the pressure of air in which is reduced by an air exhaust pump, it will boil at a lower temperature and can even be made to boil at the ordinary temperature of the room if the pressure of the air in the globe be reduced sufficiently.

Water evaporates invisibly at all temperatures, the amount being influenced by various factors, to which reference will be made later. It is a remarkable solvent, readily

dissolving gases and solids from the air and soil. This is a most important fact necessitating precautions in a public or private supply. Oxygen, nitrogen, ammonia, hydrochloric acid carbonic acid, etc., are easily absorbed. In addition to this property, it may hold in suspension mineral matters such as clay and sand, and also organic matter, *e.g.*, the lower forms of animal and vegetable life ; finally, water may dissolve certain metals, *e.g.*, lead, iron, zinc.

When bodies pass from the solid into the liquid state, or from the liquid into the gaseous, a large quantity of heat is absorbed or rendered *latent*: thus water at 0°C. equals ice at 0°C. plus the latent heat of liquefaction. For example, if equal weights of water, one at 0° C. and the other at 100°C. be mixed, the mixture will have a temperature of 50° C., but if equal weights of ice and water, the former at 0° C. and the latter at 100° C. be mixed, the mixture has a temperature of 10·6° C. only. So also steam at 100° C. equals water at 100°C plus the latent heat of vaporization, and to convert water, say one pound of it, at 100° C. into steam at 100° C., as much heat is required as would raise 965·7 lbs. of water one degree.

Water has a greater latent heat than any other substance, *i.e.*, more heat is spent in rendering a given quantity of ice liquid than in liquefying a similar quantity of anything else. These factors have a great influence in checking excessive evaporation and the too ready freezing of lakes. Water has a high capacity for heat but is a poor conductor of it. The term *specific heat* means the amount of heat required to raise a unit mass of a body through one degree in temperature. In England the standard is one pound of a substance through 1° F. In France it is one kilogramme of ice cold water through one degree C. Weight for weight, water will absorb more heat than any other substance for the same rise of temperature. The specific heat of a substance is generally greater when liquid than when solid or gaseous, *e.g.* ice has only half the specific heat of water. The latter increases with its temperature. The specific heat of a perfect gas does not

vary with its temperature or its density. For a large number of simple substances, the specific heat of equal weights is inversely proportionate to the atomic weight. In regard to solids, the specific heat is greater at a high temperature than at a low one, except in the case of platinum.

SOURCES OF SUPPLY.

Natural waters may be classified as follows:—(1) rain water; (2) surface waters, *e.g.*, rivers, streams, lakes and ponds; (3) sub-soil waters, *e.g.*, springs and wells. From whatever source, however, the water supply comes, it is ultimately dependent for replenishment on the rainfall.

RAIN WATER.

For any given temperature, air will hold only a certain quantity of aqueous vapour or moisture; the higher the temperature of the air the greater will be the amount of vapour it will hold, and when it contains its greatest possible amount it is said to be saturated. Now, if air laden with moisture be cooled, a point will be ultimately reached when the atmosphere contains as much moisture as it can retain at that temperature, and if the latter be still further reduced, the surplus moisture is deposited as rain, mist, snow or dew and the temperature at which this deposition occurs is called the *dew-point*.

Rain water carefully collected, far from aggregations of population, is generally a very pure water, being as a rule soft and well aerated. Near towns it carries down with it many impurities, especially in the earlier portions of a downpour. Near large towns where coal fires are abundant, one may find in it traces of ammonium carbonate, nitrite and nitrate, and also nitrous and nitric acids and sulphurous and sulphuric acids, but as a rule free acids are not found in the absence of factories and large collections of private houses consuming coal. Angus Smith states that the sulphates increase in amount as we pass inland before large towns are reached, and that they are due to the sulphur in the coal

consumed. He further states that the salts of ammonium increase in amount as towns increase; they come partly from coal and partly from decomposed organic substances. In the neighbourhood of the sea coast, rain carries down with it sodium chloride or common salt and also sulphates derived from the sea. As it nears the earth's surface, rain absorbs organic matter and carries with it many bacteria in suspension, as well as pollen, spores of fungi, minute particles of straw, hair, animal excrement, and sand, etc. On account of the ammonia present, the bacteria are apt to multiply rapidly; consequently, when rain water is required for internal use it should always be filtered first.

There are certain objections to the use of rain water as a source of domestic supply, among which may be mentioned:—1. Its uncertainty. 2. The prolonged dry season experienced by some countries—this involves a very large reservoir. 3. Rain water is not very palatable, and 4. Lastly much depends on where the rain falls, *e.g.*, if it falls on to a roof, it may be contaminated owing to soot, dust, decaying vegetable matter and the excrement of birds.

In favour of rain water is the fact that, in general, it is very pure and it is well aerated and soft. If it is used as a source of supply for a household, it must be remembered that near manufacturing towns its reaction is frequently acid and it may therefore act on certain metals in consequence of which fact it should not be stored in lead, iron, zinc, or galvanised iron tanks. Slate tanks with cement joints should be used, or, if the storage is on a small scale only, earthenware cisterns are good. Very large tanks should be of brick, lined with hydraulic cement and every precaution must be taken to prevent the entrance of surface or sub-soil water and also the earlier portion of the rainfall, as this is usually foul from having washed the air and also the collecting surface. If the water is to be used for drinking purposes, it must first be filtered. In Great Britain rain water is generally less pure than water from a deep well or spring because of the large amount

of smoke, effluvia, excremental dust and products of animal and vegetable decay, etc. Where rain water is stored for domestic use, rain water separators can be fixed to the rain water downtake pipe. They allow the earlier portions of the rainfall to flow away, but after a time, by an ingenious valve working on a pivot and actuated by the rainfall itself, the water is diverted into another pipe and passes to the storage cistern.

Part of the total rainfall that occurs is evaporated again from the surface, part flows along to form rivers and lakes, and the third portion sinks into the soil vertically or obliquely through fissures or pores until it reaches an impervious stratum, and then either finds its way laterally to the surface in the form of springs or accumulates in the porous strata overlying the impervious layer, where it may be reached by sinking wells.

The amount which sinks in depends on many circumstances, *e.g.*, the nature of the soil—in sand and gravel about 90 per cent., in chalk 40 per cent., in limestone 20 per cent., and in clay none. Further, obviously the proportion which sinks in is less in hilly districts where the water flows away freely. In winter a larger amount runs off the surface by gravitation than in summer, when by reason of the increased temperature evaporation is larger and the absorbent properties of the earth somewhat greater.

Experiments carried out by Tudsbery and others over a period of 14 years gave the following results as regards loss by evaporation.

The evaporation from the surface of water exceeded the rainfall in 3 out of the 14 years. The average results of the 14 years were :—

	Evaporation.		
Rainfall.	Soil.	Sand.	Water.
25.7	18.1	4.3	20.6

The small amount of evaporation from sand presents a marked contrast to that from the less permeable soil.

Throughout the year the average evaporation from roofs may be taken as 20 to 25 per cent. of the rainfall, being greatest where the rainfall is least.

The loss by evaporation from lakes providing water to Bombay City during the 8 months of the dry season may be taken as under :—

Vehar	1,700	Million gallons.
Tulsi	250	,,
Tansa	5,200	,,

and for the remaining 4 months of the year, one may reckon an additional loss of 25 per cent. of the above.

The average rainfall in Great Britain is about 30 inches. In certain parts of Assam, it is over 400 inches. At Mahableshwar, Bombay Presidency, it is over 260 inches; whereas in certain other parts of the world, rain seldom if ever falls, *e.g.*, in the Sahara and in parts of the interior of Australia.

We may assume that about $\frac{6}{10}$ of the actual average rainfall is available for storage, as a certain amount sinks into the ground—the exact amount, varying with the rapidity of the rainfall, the compactness or porosity of the soil, the steepness or flatness of the ground, the nature and quantity of vegetation upon it, and the existence or otherwise of artificial drains. A certain amount also is lost by evaporation, the degree of which depends much on the temperature of the air, its dryness and rate of movement.

The following data in connection with rainfall may be of use to the Inspector to remember :—

(1) That one inch of rain represents about 101 tons of water per acre, *i.e.*, about 4.67 gallons per square yard.

(2) The following formula may be used to calculate the amount of water given by rain, when the amount of rainfall and the area of the collecting surface are known :—

$$\frac{\text{Area in square feet} \times 144 \times \text{rainfall in inches.}}{1{,}728} = \text{cubic feet.}$$

and one cubic foot of water=6.23 gallons.

In calculating the receiving surface of the roof of a house, we must not take into account the slope of the roof but merely ascertain the area of the flat space actually covered by the roof.

(a) Area of roof in square feet $\times$ $\frac{1}{2}$ rainfall in inches=gallons per year. Or

Inches of rainfall $\times$ 2,323,200=c.ft. per square mile.

,, $\times$ $14\frac{1}{2}$=million gallons per square mile.

,, $\times$ 3,630=c.ft. per acre.

1 gall.=0.16 c.ft.=10 lbs.

(b) area of roof in square feet $\times$ rainfall in feet=cubic feet of water,

e.g.—roof space 55 square feet per head,

rainfall 27 inches=$2\frac{1}{4}$ feet,

then 55 $\times$ $2\frac{1}{4}$=124 cubic feet,

deduct 25 for evaporation=99 cubic feet,

and 99 $\times$ 6·23=gallons 617 per head per year.

SURFACE WATERS—RIVERS, STREAMS AND LAKES.

Rain falling on hills and cultivated and uncultivated lands in part goes to form lakes and rivers. As a rule surface water contains more dissolved matter than rain water. It is soft and the organic matters present are chiefly of vegetable origin. The chlorine present is low in amount; ammonia, nitrates and nitrites are generally absent except in such quantities as may be found in rain water, but if the surface water has come from cultivated lands which have been manured, then nitrates and nitrites may be present in considerable amounts. So also chlorides, if men or animals live on the collecting area.

Moorland waters may contain much peaty matter, sometimes in sufficient amount to cause diarrhœa in the consumers; moreover, due probably to the presence of certain acids, such water may give rise to lead poisoning if the distributing pipes are of that metal.

If the surface water has passed over calcareous soil, it may possess a considerable degree of hardness. As a general rule, upland surface waters are good and safe to drink and good for trade purposes.

River waters are derived in part from springs, in part from subsoil water and in part from surface waters. Snow, ice and floods influence rivers greatly.

The dissolved solids vary less than in spring water. They rarely exceed 30 to 40 parts per 100,000. As the water is derived from so many different sources, it is easy to understand that the different rivers vary in composition very greatly and the same river even in the various portions of its route. This depends largely on the tributaries, which may arise in areas of vastly different geological formations to the main stream. The dissolved organic matter is greater than in spring water, due to the influence of the surface water contribution; this may come from cultivated manured lands or from farmsteads, etc. Also in times of flood, much impurity of both animal and vegetable origin may gain access to the river. Further, when a river passes through a more or less thickly populated area, it receives a great amount of pollution from household refuse and from factories, etc. Mining operations, especially lead mines, are often the source of much pollution.

In the tropics where rivers frequently become completely or partially dried up during the dry season, there is a great risk of the bed of the stream becoming very foul from human and animal excrement and from the refuse matter of villages on its banks.

In India and certain other countries, where sacred cities are to be found on the banks of certain rivers, there is an added risk in drinking water derived from such a source, owing to the custom prevalent amongst the people, of bathing in vast crowds in the river, and rinsing their mouths with the same water in which their ablutions are performed while others go the length of drinking the same water. Very large numbers of pilgrims annually frequent these places and, as Cholera is a most usual accompaniment of any gathering of people in India and the East in general, it is not difficult to understand that Cholera may be readily disseminated by such practices. Examples of this are seen frequently at Nasik and Pandharpur resulting in the subsequent infection of Bombay through imported cases.

Generally speaking, the water of a river in the lower part of its course is less hard and more saline than the water of its upper tributaries, because the chalk held in solution by CO_2 is deposited owing to the CO_2 escaping into the air in the course of the river's flow.

SELF-PURIFICATION OF STREAMS.

It was formerly supposed that streams during their course are purified to the extent of being suitable for potable purposes. There is no doubt that to a great extent there is self-purification of water in streams but the purification is not complete, and to permit the use of such water without ensuring complete sterilization is not to be recommended.

There are various factors which contribute to the natural self-purification of streams, (*a*) Physical, (*b*) Chemical, (*c*) Biological.

Physical.

Sunlight—Sunlight has the power of exerting a germicidal effect on waters but the degree of penetration of the sunrays will depend on the turbidity and colour of the water, the direction of the sunrays, the depth of the water and other factors.

Dilution.—If a certain amount of sewage containing pathogenic bacilli is introduced into a stream, it is diluted several millions times by the abundance of water in it. Owing to the great dilution the possibilities of receiving a single bacillus in a glass of water are mathematically very remote. Moreover pathogenic bacteria do not survive more than a few days in water.

Sedimentation.—Sedimentation is constantly taking place specially in slow moving streams, containing insoluble inorganic particles such as clay. Colloidal organic matter and inorganic particles in the slow process of sedimentation gradually purify the water by entangling various bacteria and carrying them to the bottom where they die.

CHEMICAL.

Organic matter is gradually being oxidised by aerobic bacteria in running streams, and analysis of the water will reveal a dimunition in the organic matter and an increase in nitrates, to which organic matter is finally oxidised.

BIOLOGICAL.

Minute animals, *e.g* , amoebæ, infusoriæ, &c., which are present in water in large numbers live on bacteria and organic matter and help to purify the water. Various algae and lower forms of vegetable life also purify the water by living on the organic and inorganic matters.

River water contains :—

1. Suspended matters of mineral, vegetable and animal origin. 2. Dissolved gases—nitrogen, carbon dioxide, and sometimes sulphuretted hydrogen. 3. Dissolved solids—lime, magnesia, soda and potash, iron and aluminium in combination with chlorine, sulphuric, carbonic, phosphoric, nitrous and nitric acids.

The following is a very rough method of estimating the yield of a stream :—Take a part of the stream where the channel is more or less uniform in breadth and depth. Find the average of the breadth and depth in four or five places. Find the mean velocity of the stream in feet per second ; this is usually about $\frac{4}{5}$ the surface velocity and is ascertained by noting the length of time taken by a float in mid-stream to traverse a given length of the river. Now multiply the product of the average breadth and depth by the mean velocity and the result is the flow in cubic feet per second ; and cubic feet $\times$ $6 \cdot 23 =$ gallons of water.

Lake water is water which, owing to the configuration of the country-side, has accumulated in such quantities as to form a considerable collection. *Springs* may also contribute a share in their formation. The water is usually soft and free from animal impurities but may contain vegetable organic matter.

SUB-SOIL WATERS—(1) SPRINGS AND (2) WELLS.

(1) Springs or outflows of water from the earth are of two kinds :—(*a*) *Land Springs* are formed by the percolation of water through superficial porous soils such as sand, gravel or alluvial earth overlying an impervious stratum such as clay. If, when these two strata (the pervious and the impervious) come to the surface, the line of junction be tapped, a land spring is formed, as the impervious stratum below throws out the water from the pervious stratum above by hindering its further descent and causing it to flow out laterally. Such springs are usually found on the face of slopes ; they are uncertain and precarious as a source of water supply as their output depends on the extent of the available porous collecting area. They are replenished by heavy showers which do not affect deeper springs and wells ; in consequence, they are liable to become dry in prolonged dry periods. If the porous layer in one particular spot is situated too deep, a pocket may form and the level of the water in the pocket sink below the level of the outcrop in periods of drought and the spring cease to yield until a prolonged rainfall occurs.

(*b*) *Deep Springs* are those in which the source is the rain water percolating through great thickness of porous soil and collected between two impervious strata ; the presence of some fissure or fault in the overlying stratum permits of the water below it rising to the surface. Frequently, the actual collecting area is at some distance from the spring itself. Such springs are met with in chalk and greensand. As the water has generally been well filtered it is usually of great purity if surface drainage is excluded. The water is sparkling and palatable. Deep springs are preferable to land springs on account of their greater constancy and less liability to pollution. The characters of the water vary with the source. Water from Devonian rock, mountain limestone, new red sandstone and chalk may be too hard for domestic purposes. The water of deep springs coming from very great

depths is at times of a high temperature. Such springs are called Thermal springs.

(2) Wells are of two main varieties, shallow and deep. The distinction between them is differently interpreted by different people. Some term any well over 50 feet deep as a deep well, irrespective of the strata through which it is sunk, while others restrict the term to those wells only which pass through some impervious stratum to a water-bearing layer beneath. This latter definition is the one more generally accepted.

SHALLOW WELLS.

A superficial or shallow well is a well which derives its water from a permeable stratum overlying an impermeable one, but not in itself overlaid by such. The water from such a source is always more or less suspicious and in many cases distinctly bad. For convenience, wells are often sunk in the immediate vicinity of habitations, stables, etc. In Bombay City there are many such wells sunk in the ground floor of houses. There are many sources of possible contamination, under the circumstances, usually associated with superficial wells, *e. g.*, the ordinary impurities of the soil of towns, leaking drains, cesspools, middens, neglected basket privies, manure heaps of stables, pig styes, burial grounds and decaying vegetable and animal matter. The habit of performing personal ablutions and of cleansing garments at the mouth of insufficiently protected wells is also a source of risk.

As the rain water penetrates the ground, it tends to descend until, sooner or later, it meets an impervious stratum which arrests its downward movement and tends to divert it laterally, and as the sub-soil water steadily moves in the direction of its natural outflow depending on fall of the stratum in question, the location of any cesspool, stable, burial ground, etc., above the well must naturally lead to contamination of the latter, depending of course on the distance away and on the amount of demand made on the well and porosity of the soil in question. Another frequent source of possible

contamination is the custom of using private vessels to withdraw water from a well; much pollution may thus be introduced by ignorant and careless people.

The *Koas* or Moat system of drawing water from a well also leads to contamination of the water, owing to the amount of dirt which must necessarily adhere to the rope as the bullocks walk backwards up the incline leading to the well.

Again, the custom of planting trees in such a position as to overhang wells results in pollution of the water by decaying vegetable and animal matter.

The organic matter found in superficial well water is generally of animal origin. Water which has soaked through sand and gravel may be impure from contained ammonia, chlorides, nitrates and nitrites.

It must always be remembered that the source of pollution may be situated at some considerable distance from the well or spring. Leaking cesspools, manure steads, etc., may through faults in the strata, etc., discharge a portion of the contents into a well far away. There are various methods of detecting any suspected source such as this. Chemical substances are introduced at the suspected source and their presence in the well water is subsequently looked for, after having taken the precaution of ascertaining the presence or absence of these substances in the water prior to the experiment. Lithium chloride, flourescin and common salt are the substances most usually employed. The presence of lithium in the well water is ascertained by the spectroscope, that of salt by the silver nitrate test, and that of fluorescin by the fact that this substance gives a green fluorescence in the presence of an alkali. Dr. Beam of the Gordon College, Khartoum, has introduced a very delicate test for the slightest trace of this substance. He found that the concentrated water of the Nile was too highly coloured to permit of accurate observation under the method usually employed. His method is as follows :—Evaporate one or two litres of the water to small bulk and add a few drops of caustic soda and

then continue the evaporation to dryness over a water-bath. Now add 5 to 10 c. c. of absolute alcohol and heat the dish bringing the alcohol into contact with all parts of the water residue. The liquid is now passed through a small filter. In the absence of fluorescin, the alcohol remains perfectly colourless, but if this substance is present, a distinct fluorescence is imparted. McCrae and Stock, experimenting in South Africa, placed fluorescin in the suspected area of contamination and pumped the neighbouring wells. They preferred a dark background to detect the fluorescence. They noted that the water required to be concentrated before the test was successful; further, that the addition of an alkali is essential, as the characteristic fluorescence is not seen in acid solution. The green colouration sometimes produced by iron must not be mistaken for that of fluorescin.

Instead of chemicals, occasionally comparatively harmless species of bacteria are introduced for the same purpose, *e.g.*, the bacillus prodigiosus, and its presence is subsequently sought for in the well or spring water.

A well drains an area like an inverted cone, (the cone of filtration) the radius of which is equal to at least 4 times the depth of the well. If the well be too much drawn upon by pumping, then this area of drainage is greatly increased, thereby adding to the risk of tapping some source of contamination such as a cesspool, manure stead, etc., situated some considerable distance away.

A sudden rise of ground water may cause direct communication between a shallow well and a cesspool not previously tapped..

In peaty districts, the water from such a well may be brown due to vegetable matter.

To roughly estimate the yield from a well, pump out the water as rapidly as possible and allow it to refill to its former level, noting the depth to which the water had sunk and the time taken in refilling. The quantity of water brought in within the time noted, is obtained in cubic feet,

by multiplying the surface area of the water in square feet, by the depth in feet to which the water level had sunk as a result of pumping. Cubic feet multiplied by $6 \cdot 23$ = gallons.

By this means one can roughly estimate how many gallons will be available in a given time.

PRECAUTIONS TO BE TAKEN IN REGARD TO SUPERFICIAL WELLS.

The well should not be closer to a drain than 4 feet for every foot in depth of the well, *i.e.*, a 25-feet well should be at least 100 feet away from a drain. A well should be 200 feet from any cesspool or cemetery.

The ground for a radius of 30 feet round the mouth of the well should be cemented, or paved with stone slabs set in cement, with a proper slope leading away from the well, and adequate provision must be made for carrying away any waste or surplus water falling on this surface, so as to prevent the water gaining access to the well and also to prevent the breeding of mosquitoes owing to the accumulation of stagnant water in the vicinity of the well. The actual edge of the well must be protected by coping stones at least $2\frac{1}{2}$ feet high to prevent access of surface water to the well. No private vessels should be used for abstracting water and, where the water is for domestic use, it should not be withdrawn from the well by the usual village practice of employing oxen (*Moat* or *Koas*).

Trees should not be allowed to overhang a well or to be so near as to permit the leaves falling in.

The mouth of the well ought if possible to be closed, not only to prevent the entrance of dirt, or dirty vessels, but also to obviate the risk of mosquitoes breeding therein. By far the best measure is to permanently close the well by a concrete covering, leaving only a small trap door for purposes of inspection and cleansing (which door should be cemented down), the water being drawn by means of a pump.

The well should be lined either with bricks set in cement with a backing of puddle, or with earthenware tubes or cement or iron cylinders, to prevent the entrance of water except from the bottom or near it.

Moreover, behind the cement or brickwork lining, there should be a layer of puddled clay as an additional precaution.

In villages, if possible, all shallow wells should be surrounded by an acre of uncultivated and uninhabited land, no privy or cesspool being allowed within this area.

Koch, recognising the danger of superficial wells in times of epidemics, strongly advised that existing shallow wells be converted into tube wells. He proposed the following method of conversion. The well to the level of high water mark should be filled in with pebbles and gravel, and above this, and reaching right to the top, should be placed sand. To obtain the water, an iron pipe must be placed in the well extending down through the sand and gravel to the bottom. This tube is connected to a pump. By this means Koch claims that much danger from Cholera can be obviated.

As a general rule, the site selected for a surface well ought to be as far removed as possible from all sources of contamination, and in a direction opposite to the natural course of the subsoil water, so as to tap it prior to its reaching any possible source of contamination present in the village.

DEEP WELLS.

As already mentioned, the term refers more to the fact that the well is sunk through one or more impervious strata rather than to any measure of its actual depth. The water obtained is generally pure and free from organic impurities, provided proper measures are taken to render the upper portion impervious and to prevent the entrance of surface water. The water varies in composition according to the strata it passes through.

In chalk the water is clear, sparkling, and wholesome. It contains calcium carbonate and carbon dioxide. In limestone and magnesium limestone it is good; it however

contains more calcium and magnesium sulphate than that from chalk.

From granite, metamorphic and trap rock it is very pure. It contains some sodium chloride and carbonate and but little lime and magnesia.

From millstone grit and hard oolite the water is very pure, the salines present being chiefly calcium and magnesium sulphate and carbonate.

The temperature in deep wells increases about 1° F. for every 55 feet in depth below 60 feet, at which depth it is fairly uniform at 50° F. Deep wells should be lined with bricks, stone, steel, socketed wrought iron or steel pipes to a point at least lower than the lowest water level. If with bricks, they should be hard, well shaped, and well burnt and laid in good hydraulic mortar. To exclude land and other springs, etc., concrete or clay puddle must be introduced behind this steining. The sides of the well should be steined as far down as the top of the impermeable layer.

To increase the yield from a well already executed, one or other of the following measures is usually adopted :—

(1) Lower the water level in the well by pumping whereby the hydraulic depth for the inflow is increased.

(2) The bore hole may be deepened.

(3) Headings may be driven laterally from the well.

Artesian or flowing well, so called from Artois in France where they were first dug, is a variety of deep wells in which the water is tapped in a permeable stratum lying between impermeable strata. The water-bearing stratum is basin-shaped and its outcrop which is a great distance away is at a higher level than the site of the well. Consequently the water tries to gain its level and actually sprouts at the mouth of the well.

ABYSSINIAN OR TUBE WELLS.

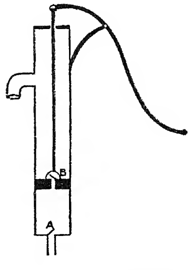
These consist of a hollow iron tube, of a diameter varying between $1\frac{3}{4}$ and 3 inches, which at its lower end, has a steel

pointed projection for the purpose of boring. The tubes are driven into the ground by heavy iron weights suspended on a pulley. The lower portion of the tube is perforated to admit of the entrance of water. A tube is driven in until a water bearing stratum is reached and if necessary successive lengths of pipe are attached to the original. The water is derived from the stratum direct. Such wells are useful when the superficial supplies are known to be polluted. When a water bearing stratum is reached, a pump is attached.

Various boring operations, are done by the Government of Bombay annually, either to augment the yield of existing wells or to ascertain the nature of foundations. The boring at Asalgam, for instance, was continued and an artesian supply of water at the rate of 129,600 gallons per day was encountered.

The insertion here of a few notes on the general principles of action and construction of various types of pumps may be of interest.

There are two types of pumps—the suction or atmospheric and the force pump. The former answers the purpose well, so long as the distance the water has to be raised does not exceed 25 feet.

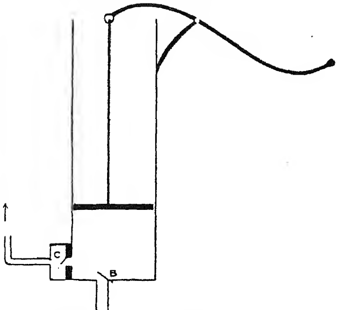


The suction pump, or atmospheric or lifting pump, consists of a cylinder called the barrel, with a valve A, in which works a piston or box in which is another valve B. Both valves open upwards. The piston is attached to a rod which is worked by a handle. When this is raised, the piston is depressed. The valve B then opens upwards allowing the water or air below

it to escape into the upper part of the cylinder. When the piston is raised, the valve in it closes and the water above the valve is lifted up and discharged through the spout. The water from below, owing to atmospheric pressure on its surface, lifts the valve at A and rushes up to fill the vacuum caused by raising the piston. When the piston is again depressed, the same process is again repeated. If the valves are very dry, a little oil should be poured on them. A small quantity of water poured on the piston before commencing work makes it air-tight. This form of suction pump is frequently used in shallow wells. It is suitable for hand power only. The surface of the water to be raised should not be more than 25 feet below the moveable valve. Where the water level fluctuates, care must be taken to measure from the lowest level reached during those fluctuations. Especially for small pumps, the suction pipe should fall all the way from the pump to the supply well, as any upward bend in the suction pipe introduces an air trap and may seriously interfere with the power of the pump.

THE SINGLE ACTION FORCE PUMP.

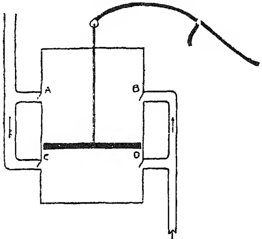
This pump is used to force water up to the top of high buildings, etc. In this pump the piston is made without a valve. The pipe for delivering water is at the bottom of the pump. It has a valve C which opens upwards so as to prevent the return of the water in the delivery pipe. At the bottom of the cylinder is a valve B opening upwards. When the piston is raised, valve B opens and the water rushes into the cylinder; when, however, the piston descends, valve B closes and valve C opens and the water is thus forced up the delivery pipe. In this pump the force is required for the down stroke. The top of the cylinder need not be closed, as a little water poured in above the piston renders it air-tight. Sometimes a solid plunger is substituted for the piston to avoid the expense of turning the cylinder true and also because it resists the wear from dirt and grease better. At each stroke it raises a volume of water equal to that of the plunger.



SINGLE ACTION FORCE PUMP.

THE DOUBLE ACTION FORCE PUMP.

This pump forces up water both at the up and down strokes. At the up stroke the water above the piston is forced through the valve A, while that below enters the cylinder at the valve D. At the down stroke the water is forced through the valve C, while it enters above the piston at the valve B. In all force pumps, the packing of the piston or box is of the utmost importance. It is commonly made of waste tow soaked in tallow rammed tight, but for great pressures cup leather packings are used.



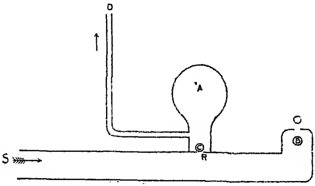
DOUBLE ACTION FORCE PUMP.

CENTRIFUGAL PUMPS.

These pumps contain no valves and no pistons. They work by the revolution of a series of blades contained in an iron casing. A partial vacuum is produced behind the revolving blade and water is drawn in due to atmospheric pressure upon it, while the water in front of the blade is forced into the rising main. These pumps are very good up to 25 feet. Some are made which are capable of raising water up to 100 feet.

THE HYDRAULIC RAM.

Rams are used to lift water to heights as a rule not exceeding 150 to 200 feet, but special rams are made for greater heights. The principle on which they work is as follows (*vide* Diagram) :—The water working the



ram is supplied through a pipe S and it escapes through the opening O until it has gained a velocity sufficient to raise the valve or ball B, which suddenly stops the current in this direction and causes an excess pressure in the ram R which results in the valve C being raised. The water is then pressed into the air chamber A and finally through the delivery pipe D to its destination. When equilibrium of pressure is established between S and R, the valve B falls and the operation is repeated. The ram, depending on its size, can make as many as 200 strokes per minute. The intermittent flow through C is converted by the pressure of the air in A into a constant flow in the pipe D. The length of the supply pipe may be ten times the height of the fall or more, but it must not be less than 5 times the height.

Any working fall from say, 18″ up to 100 ft. will do to work a ram, but the more the fall obtained up to about ⅓ of the total height that the water has to be raised above the ram, the less will be the cost to raise a given quantity and the less will be the driving water required to lift that quantity. Rams will force water to a point several miles distant. The quantity of water required to work a ram depends on the fall available, the height it is required to raise the water and the quantity desired to be raised. Under favourable circumstances, rams can be made to work with less than one gallon of water per minute. When giving the quantity of water available to work a ram, it is necessary to state also the velocity and flow in gallons per minute. When the working supply is not sufficient to work a ram continuously, the water may be dammed up and discharged at intervals the ram thus working in intermittent manner.

The ram is cheap and well adapted to small villages and country houses. The elevation to which the water has to be raised must not be too great, otherwise repairs to the working parts will be frequently needed.

In actual practice, it may be said, that water falling from any height between 4 and 40 feet may be made to raise a portion of itself to any greater height up to 10 times the amount of fall available.

A well-made ram is very durable and requires but little attention and its cost should not exceed Rs. 700 to 800.

HARDNESS OF WATER.

The provision of a hard water supply for a town reacts in various ways. In the first place a very great waste of soap occurs. The constant use of a hard water for drinking purposes causes gastro-intestinal troubles; vegetables boiled in hard water lose much of their colour and flavour. The same amount of nutriment is not extracted from meat, nor flavour from coffee or tea, with a hard as with a soft water. Hard water used in boilers may cause an explosion due to the

deposition of salts, which usually occurs in the following order :—(1) The carbonates of calcium and magnesium. (2) The sulphates of calcium and magnesium. (3) Salts of iron, if present. (4) Silica or alumina, if present. The incrustation formed causes much waste of coal.

The total hardness of most water is caused by salts of calcium and magnesium with some free carbonic acid; hence waters from chalk, oolite, limestone, dolomite, and new red sandstone are hard. Rain water is soft.

It is estimated that every degree of hardness means waste to the extent of one pound of soap for every thousand gallons of water used.

Hardness of water is of two kinds (1) temporary and (2) permanent; the former is capable of being removed by boiling or by the employment of caustic lime or soda.

Temporary hardness is due to the presence in the water of the carbonates of calcium and magnesium held in solution as bicarbonates by carbonic acid chiefly. The bicarbonates of calcium and magnesium cease to be soluble at 212° F. and after treatment of the water with caustic lime or soda, as they are robbed of a portion of the carbon dioxide which holds them in solution, they are deposited as mono-carbonates.

The permanent hardness is due to calcium and magnesium sulphate, chlorides, phosphates and nitrates with some magnesium carbonate which re-dissolves as the water cools. The salts of iron, silica and alumina, if present, also add to the hardness. All these salts are unaffected by boiling, thus constituting the difference between temporary and permanent hardness. To determine the amount of hardness present, a solution of soap is used. Soap is a salt of an alkali with one of the fatty acids, *i.e.*, soap is an alkaline oleate, soluble in water forming with it a lather. If lime, baryta, alum, magnesium or iron be present, oleates of these bases are formed

and no lather is given until the earthy bases are thrown down or used up. Free carbonic acid has the same effect. The precipitate formed with calcium comes down direct, but that formed by magnesium comes after a slight delay, hence an apparent lather may form only to disappear later. Many of the salts contributing to the total hardness are held in solution by carbonic acid, *e.g.*, the carbonate and some salts of lime and magnesium and some of silica, alumina and iron if present.

The amount of hardness may be expressed in terms of grains of calcium carbonate per gallon. This is known as Clarke's system, where each grain per gallon equals one degree Clarke; or it may be expressed as parts of calcium carbonate per 100,000. This is known as the metrical scale. When they are compared, 1° Clarke =0.7° metrical.

The total hardness of a water should not exceed 30° metrical and of this the permanent hardness should not exceed 5° metrical.

Hard waters vary from 20° to 30° metrical and soft waters from 8° to 15°. A very soft water may contain from 6° to 8° metrical. The greater the permanent hardness the more objectionable the water.

TREATMENT OF HARD WATERS.

Temporary hardness can be dealt with by caustic lime or soda, which robs the bicarbonates of one molecule of carbon dioxide and reduces them to monocarbonates.

A water containing bicarbonate of magnesium:—

$MgCO_3.\ CO_2+CaO=MgCO_3+CaCO_3.$

A water containing only bicarbonate of calcium:—

$CaCO_3.\ CO_2+CaO=2CaCO_3.$

Water treated by caustic soda:—

$CaCO_3.\ CO_2+2Na_2OH=CaCO_3+Na_2CO_3+H_2O.$

A water containing sulphate of lime can be dealt with by carbonate of soda, with the result that a monocarbonate

of lime forms and sulphate of soda, a soluble salt, remains in solution.

$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$.

A water containing both bicarbonate and sulphate of calcium :—

$CaCO_3 . CO_2 + CaSO_4 + 2NaOH = 2CaCO_3 + Na_2SO_4 + H_2O$.

One must know the exact degree of hardness in the water and use only so much lime, etc., as will combine with the carbon dioxide holding the chalk in solution—otherwise lime will pass out into the distributing pipes.

The average amount added is about 1 oz. of lime per 700 gallons of water for each degree of temporary hardness.

There are several commercial processes (Clark's, Porter-Clark's, Lawrence's, Stanhope's, &c.) for softening water.

In Clark's process quicklime is slaked with water in a tank and the water to be softened is gradually added and thoroughly mixed mechanically. After allowing to settle for twelve hours the clear supernatant water is tested for uncombined lime by adding silver nitrate solution.

In the Porter-Clarke process the suspended matters obtained as in Clarke's process are removed by passing the water under pressure through linen cloth. This process does not touch the permanent hardness.

The Stanhope Water Softener reduces the temporary and permanent hardness by using lime and soda.

An efficient and automatic method of softening water for domestic purposes is the "Permutit System".

Permutit is a compound of Silica and Alumina with various bases and its mode of action depends on the property of "base exchange." Soda Permutit for example when brought in contact with hard water, takes up the Calcium and Magnesium and gives Soda to the water in exchange and thereby softens the water, the action being automatic. When exhausted the Permutit can be rejuvenated by boiling it with 10 per

cent. salt solution when the Calcium and Magnesium are eliminated as chlorides, and Soda Permutit is reformed.

Manganese Permutit is effective for removing iron from water.

ACTION OF WATER ON LEAD PIPES, ETC.

Certain waters act on lead and also on zinc.

Those waters which act most are—

- the purest and most highly oxygenated, *e.g.*, rain water, and the soft waters of lakes and upland surfaces;
- those containing any organic matter, nitrites or nitrates from sewage pollution;
- waters containing much of chlorides which dissolve the coating of carbonates which may have formed;
- waters containing any free acid, *e.g.*, peaty water.

Water containing mud and mortar appears to act more on lead. Moorland gathering grounds are usually rich in peat. Moist peat is invariably acid in reaction, and water draining from peat is always acid. The degree of acidity depends chiefly on the amount of peat and the length of time the water has been in contact with it; the cause of it is the growth in the peat itself of acid producing bacteria.

Those waters which act least on lead are—

- those rich in the earthy salts, *e.g.*, hard waters from deep wells containing carbonates, phosphates and sulphates, especially calcium carbonate.
- those containing free carbonic acid not in excess. If the CO_2 is in excess or the water is charged with it under pressure, then the coating of protective basic carbonate is dissolved and the solvent action of the water is increased.

Silica is said to have a protective influence.

New lead pipes yield more lead to the water than do old pipes. The length of time the water is in the pipe also influences the result; for the first 24 hours the amount dissolved

increases, but afterwards some is deposited and after the lapse of about 6 days less is found. Hot water in pipes takes up more lead than cold. Increased pressure upto 140 lbs. per square inch helps the solvent action of the water. The juxtaposition of other metals to lead increases the solvent action owing to galvanic action; this is seen when iron, zinc or tin is mixed. Bending lead against the grain is said to increase the risk. Zinc pipes, which often contain a mixture of lead, may yield that metal to the water.

Lead has a cumulative action on the human system. The amount of lead necessary to cause illness varies very greatly according to the personal idiosyncrasy of the individual concerned. Angus Smith quotes a case where water containing $\frac{1}{100}$ grain of lead per gallon caused poisoning. Adams also records a similar case. Any quantity over $\frac{1}{20}$ grain per gallon (*i.e.*, 0.07 per 100,000 parts) is to be considered as bad. As different observers report water analysis in different terms, *e.g.*, some in terms of grs. per gallon, while others do so in terms of parts per 100,000, it is convenient to remember that to convert grains per gallon into parts per 100,000, one must multiply by 10 and divide by 7.

To prevent the absorption of lead various devices have been proposed, including those acting on the water before it enters the pipe and those acting on the pipe itself:—

1. Limestone, lime, or bicarbonate of soda is added to the water in order to lessen its acidity.
2. Lead pipes lined with tin have been recommended, but as the lining is liable to fracture, galvanic action may be set up and lead dissolved. Block tin pipes besides being expensive are liable to corrosion if the water contains nitrates. Tin lined iron pipes have been used in many places. On the whole, the best is to have good iron pipes protected in one of the various ways in vogue. Filtration through sand, charcoal, or spongy iron will remove much of the lead.

Action of Water on Iron Pipes.

The action appears to be energetic at first but diminishes later. Soft waters act freely on cast iron, causing corrosion and consequent turbidity of the water and diminution of the thickness of the pipe. Waters with little lime but high chlorides act rapidly on iron. They acquire a ferruginous taste and leave a deposit of red oxide of iron in vessels. Different methods have been adopted to protect iron pipes from corrosion.

Angus Smith's protective process consists in coating the interior of the pipe with a mixture of pitch, resin and linseed oil. As a result the corrosive action of the water is lessened. The pipes are heated to 310° F. and are then immersed in a bath of pitch for some time. This bath must be kept at a temperature of not less than 310° F. and the pitch used must be distilled until all the naptha has been driven off the coal tar. The pipe must be perfectly clean and free from rust before immersion.

Barrf's protective process consists in raising the temperature of the pipes to 1200° F. in a suitable chamber through which superheated steam is passed for several hours—after which treatment a coating of oxide of iron is formed.

In some parts of the United States of America, iron pipes lined with hydraulic cement are used.

On the whole, iron pipes are best for the larger sizes required, and, under the pressure of the constant system, for the smaller sizes also.

Quantity of water required per head of population.

The amount of water supplied to larger towns varies with the facilities of supply and the demand.

It must of necessity vary according to circumstances of climate, the presence of trades and large institutions, etc. Water is required for ordinary domestic purposes including personal ablutions, cooking, cleansing of the house and clothing and for water-closets and baths. Municipal requirements

must be met, as water is needed for the streets, for cleansing drains and sewers and for extinguishing fires. Provision must also be made for animals, *e.g.*, horses, cattle and dogs. Finally, trade requirements and an allowance for waste must be met. It is not possible to lay down any hard and fast standard of requirements; a rough guide, which however must vary according to circumstances, is for domestic, municipal and trade purposes 10 gallons each per head.

In an ordinary residential town in England 25 gallons per head per day, including water for water-closets, is considered sufficient and is distributed thus:—

	Gallons.
Cooking	.7
Drinking	.3
Ablution..	5.0
House cleaning	3.0
Laundry	3.0
Baths	4.0
Water-closet	6.0
Waste	3.0
	25.0

To this should be added 5 gallons per head for Municipal purposes—flushing of drains and road-watering and fire and, if a manufacturing town, another 5 gallons per head per day, making in all 35 gallons per head per day.

In large manufacturing centres with railway and docks, another 5 gallons should be added.

In India, owing to the habits and customs of the Indian, an extra item in the allowance for waste is made, as he cannot resist letting the tap run all the time he is washing himself or his clothes, and there is besides the underground waste due to defective fittings and pipes. So that in a large city in India—Bombay and Calcutta—a supply of 50 gallons per head should be estimated for, but in other towns and cities a supply of 30 or 40 gallons is ample.

The following table shows the average allowance per head in each of the following towns:—

London	37	Edinburgh	50
Liverpool	34	Dublin	35
Manchester	36	Newcastle	33
Glasgow	56	Rome	220
Paris	44	Calcutta	35
Berlin	22	Madras	28
Vienna	22	Bombay	80

In the case of Calcutta, Madras, Bombay and other towns in India, the amount of water actually used per head is greatly in excess of the amount provided by the respective Municipalities, as a large amount of water is extracted from private wells and public tanks for ordinary domestic purposes, washing and for the watering of gardens.

In Bombay it is beyond question that a reckless waste of public water is practised by the poorer classes.

THE COLLECTION AND STORAGE OF WATER.

Where the water supply is derived mainly from surface waters, it is necessary to provide sufficient storage where any aggregation of population occurs, in order to meet the demands for water. Water is therefore collected in what is known as an "impounding reservoir," which is usually constructed by damming the lower end of a valley.

Many considerations have to be weighed before settling on any particular site as suitable for an impounding reservoir, and though these fall more particularly within the duties of a Water Engineer, brief reference may be made here to a few of the main points.

(i) In the first place, one must know the amount of rainfall experienced in the area under examination, its seasonal distribution, the greatest annual rainfall, the least and the average, and also the length of the dry season.

Hawksley has estimated that, speaking generally, the average of 20 years' rainfall less $\frac{1}{3}$ may be taken as the

amount of rain in the driest year, that similarly the average of 20 years plus $\frac{1}{3}$ equals the amount in the wettest year, that the average of the 3 driest years in 20 is a fairly safe basis to work upon, and that this may generally be taken to be about $\frac{5}{6}$ the average rainfall. We may assume that about $\frac{6}{10}$ of the actual average rainfall is available for use.

(ii) The extent, configuration and nature of the catchment area must be carefully ascertained. The nature of the soil influences the loss by percolation, which is greatest where the soil is porous, *e.g.*, sand and gravel. A steep rocky surface occasions least loss by evaporation and percolation. The ground must be examined to ascertain the nature of the underlying impervious stratum and its distance from the surface and, if possible, the presence or absence of any fissures should be ascertained.

It is most desirable that no part of a catchment area should be under cultivation, nor should any human habitations be permitted in the area. The houses necessary for the Water Engineer's permanent staff should be so situated as to preclude any risk of drainage from them entering the lake. The area should be fenced in to prevent cattle straying into it and it should be covered by evergreen trees to protect the soil from being washed away.

(iii) The extent of the demand (if any) for compensation waters must also be ascertained and provided for.

The sides of reservoirs should slope rapidly, and preferably should have a rubble-covering to a depth of 6 to 10 feet below low water mark. In very large reservoirs, however, this is often impracticable.

The margins should be kept free from weeds and long grass.

In impounding reservoirs the growth of chara and nitella may cause an offensive smell and taste to be imparted to the water. Soft waters and those with ammonia in them aid the growth of these low forms of vegetable life.

Blue and green algæ frequently grow along the sides and diatoms and desmids on the surface.

To destroy algæ, etc., copper sulphate in the strength of 10 lbs. for every million gallons of water is of great value. It is usually mixed with the water by towing canvas bags over the lake behind a small boat or boats.

The decay of blue algæ causes an objectionable smell which is noticeable also when the oil sacs in them are ruptured. After water containing blue and green algæ has been treated with copper sulphate, the smell may appear to be worse, but in a week the water will be found to be quite free from smell, sediment and any trace of copper. Filtration through polarite as well as any mechanical filters, *e.g.*, Jewell's removes copper.

Water from reservoirs, rich in bottom vegetable growth frequently has an offensive odour, for which the only remedy is thorough aeration.

A method of getting a very rough estimate of the amount of reservoir space required is as follows:—Divide the number of gallons of water used daily by 6.23; this gives the number of cubic feet consumed per day, and that multiplied by the number of days for which storage is required gives the reservoir space necessary. Hawksley introduced a formula whereby one can ascertain the number of days' supply that should be stored in any particular instance. Let F equal the mean annual rainfall in inches, say $\frac{5}{6}$ of the average annual yield, and let D equal the number of days for which storage is required, then

$$D = \frac{1{,}000}{\sqrt{F}}$$

e.g., the mean annual rainfall is 25 inches, then

$$D = \frac{1{,}000}{\sqrt{25}} = 200 \text{ days.}$$

In England, the minimum number of days for which storage should be provided is usually about 150 days.

From impounding reservoirs the water is taken to storage reservoirs, from whence it may pass to filter beds, or in some instances direct to the consumer through street mains and service pipes, etc. Pumping stations and settling tanks may or may not be necessary, according to the elevation of the impounding reservoir and the purity of the water. As far as possible all storage reservoirs should be covered in and ventilated, they should be deep, and not extended and shallow, so as to lessen evaporation and keep the water cool. They should be periodically cleansed. Further reference will be made to the importance of storage reservoirs under the heading of "Purification of Water."

When the supply of water is derived from a river, the intake should be where the stream is constantly flowing, avoiding stagnant and shallow places. It is best situated some feet below lowest summer level. Screens should be provided to exclude gross matter entering. The water may have to be pumped to subsidence and storage tanks, passing thence to filter beds and to the clear water storage reservoir and thence to the public.

DISTRIBUTION OF WATER.

There are two main systems, and several subsidiary methods of distributing water, such as by water carts, *pakhals*, etc. The main systems are (1) the constant and (2) the intermittent, the essential difference between them being that in the latter there must be provision made in the house for the storage of one or more days' supply of water, whereas in the constant system the storage required is only to the extent of the cisterns necessary for the water-closets and kitchen boilers.

In the constant system, the taps in the houses deliver water direct from the service pipes. This system necessitates a good supply of water, good pipes and fittings and strong taps. Any wastage is generally due to leaks in the pipes resulting from fracture and drawn joints or defective taps.

Such leakages are generally detected by sight or by the use of waste-water meters. Among the objections raised to the constant system are the waste that may occur and the loss of control in times of shortage of water. The former can and should be controlled to a great extent by waste-water inspectors and by the compulsory use of strong fittings, and the latter is capable of control by curtailment of hours of supply should necessity arise.

The intermittent system is open to many objections: in the first place it causes corrosion of the pipes, resulting in diminution of supply and turbidity of the water.

The cutting off of the water tends to create a vacuum in the pipes; consequently, if there is any fracture in the pipes or a leaking joint, there is great risk of foul air or coal gas or even sewage being sucked into the pipes. In actual practice, outbreaks of disease have been traced to this very cause.

The intermittent supply is in itself a great source of waste, as people leave the taps open on finding no supply on. Consequently, when the supply does come much waste may result.

Another very serious objection is that this system necessitates the use of cisterns for the storage of water during non-supply hours. Cisterns are apt to get foul, are costly and moreover the water is apt to stagnate in them and absorb impure air. Besides in many of the homes of the poorer classes there is no room for cisterns. Where cisterns are necessary, they should be so placed as to be readily accessible for purposes of cleansing, which process should be carried out at regular intervals. They should be covered so as to keep out dust, insects, vermin and the droppings of birds, etc., and also to prevent the breeding of mosquitoes. Provision can be made for ventilation by means of a curved pipe. They should be placed at the top of the house, and if this be a high one, provision must be made for filling them by a force pump worked either by hand or by electricity.

No cistern supplying a water-closet should be allowed to supply the drinking water of the house as well. Here one may add that on no account should a tap from a service pipe ever be allowed to directly flush a water-closet.

Every cistern should be supplied with an overflow pipe opening directly into the open air, so as to give timely warning of any waste. This pipe must never open either into or over a drain or sewer.

Frost may interfere with the action of a cistern, and if the kitchen boiler is supplied direct from the cistern at the top of the house, much trouble may result from a severe frost such as is experienced in certain parts of India. A separate cistern placed at the back of the range should always be provided in places exposed to severe frosts.

Cisterns are constructed of various materials: stone, cement, brick, slate, tiles, wood and lead, zinc and iron, etc. Of these, slate is perhaps the best, but it is liable to leakage; it should be set in hydraulic cement or in Spence's metal; common mortar should not be used as it may cause the water to become hard. Lead cisterns are open to the objection that certain waters act freely on them. Zinc and galvanised iron cisterns are liable to corrode, and if the water is rich in nitrates, zinc salts may be dissolved in the water. Wooden tanks should not be allowed. Iron cisterns are apt to corrode.

Spence's metal is made by melting the three sulphides of iron, zinc and lead with sulphur. It expands in congealing and so is very useful for jointing water pipes, etc.

When the pressure of water in the main is not constant and varies in different parts of the city, it is necessary in the case of dwellings over 50 feet high to resort to artificial means of raising the water. This can be done by hand-pump, gas-engine and electric power. All these methods are in use in every city, and in Bombay they can be seen at work both in European houses, flats and hotels and in the Indian part of the city. The town supply is delivered into tanks

placed at the ground level or below it and the water forced up to a cistern on the roof.

SOURCES OF IMPURITY IN THE WATER SUPPLY.

These may have their origin in the geological strata from which the water is derived, or from the manner of storage or distribution.

IMPURITIES FROM GEOLOGICAL STRATA.

Mountain limestone yields a clear palatable water, which however is rather hard and therefore unsuited for many trade and domestic purposes. So also water from hard oolite, cretaceous rocks and chalk is hard. Water from magnesium limestone contains a large amount of permanent hardness. That from gravel is very variable and usually contains much organic matter. Shallow wells in alluvial and gravel soils generally yield an impure water, containing calcium carbonate and sulphate, sodium carbonate and chloride, magnesium sulphate and traces of iron and silica and often much organic matter. From cultivated land, the water contains much organic matter and salts. The water of marshes contains much vegetable organic matter. Wells near cemeteries may yield a water containing ammonium and calcium nitrites and nitrates and sometimes fatty acids and much organic matter. That from old cemeteries contains less organic matter, but much nitrates and chlorides, and speedily becomes putrid. Wells near the sea may give a brackish water.

IMPURITIES OF STORAGE.

One of the great objections to the intermittent supply of water is that this system necessitates the presence of cisterns. These are very apt to become neglected and be a source of danger, as already mentioned. Storage in underground tanks, which are not properly constructed so as to exclude surface drainage or drainage from leaking cesspools, also permits of pollution of the water. The material of which the tank is constructed may also have this effect. Open tanks

are very liable to pollution from the habits of the people bathing there and washing their clothes therein; moreover, many are so insufficiently protected as to permit of surface drainage gaining access.

POLLUTION DURING DISTRIBUTION.

Distribution by means of open conduits is attended with considerable risks, as such are liable to be fouled by surface washings, leaves and branches of trees, dead animals, house and trade refuse and human and animal excrement.

The possibility of water dissolving iron, lead and zinc when passing through pipes composed of those metals or stored in cisterns thereof has been discussed elsewhere. Defective pipes and joints may admit of pollution, if water pipes are permitted to be laid in the vicinity of cesspools and drains, etc.

Sewer gas, sewage and coal gas may all be drawn into water-pipes when the intermittent system of supply is in vogue.

DISTRIBUTION BY SKINS (*Mashaks*).

Leathern receptacles made of the skin of the goat or calf are used.

The sources of pollution are more or less obvious, as the skins are unclean to commence with and cannot be made or kept clean. Moreover, during non-working hours the *mashaks* are deposited anywhere, and, should an outbreak of Cholera or Typhoid occur in the house of the *bhisti*, the chances of infection of these receptacles are very considerable.

DISTRIBUTION BY WATER CARTS AND BARRELS.

The chief risk in such cases lies in the difficulty of keeping such receptacles clean. As a general rule, precautions are absolutely neglected and the carts become very foul.

Periodical cleansing and strict inspection tend to minimise the risk.

Effects of an Insufficient Supply.

The effects of an insufficient supply are more or less obvious. Personal cleanliness of body and clothing diminishes. Eating utensils are not properly cleansed. The cleanliness of the house suffers. The streets are not watered, increasing thereby the nuisance and danger from dust. The sewers and drains are not flushed, and these add to the vitiation of the atmosphere. The result of all these factors is a lowering of the general health. Skin and eye diseases spread. Typhus, Enteric, Diarrhœa and Relapsing Fever increase. The damage from an outbreak of fire is also increased in the case of shortage of water.

Effects of an Impure Supply.

The diseases which are associated with the use of impure water are Cholera, Enteric, Dysentery, Dyspepsia, Diarrhœa Goitre, Metallic Poisoning and Parasitic diseases.

Diarrhœa may be due to suspended mineral matter, *e.g.*, clay, marl, etc., examples of which may be seen in the effects of the waters of the Ganges, Missisippi and the Orange Rivers.

Suspended animal and vegetable matter and also dissolved organic and mineral matters may cause diarrhœa, *e.g.*, hydrogen sulphide, calcium and magnesium sulphate, calcium and potassium nitrate.

That Dysentery, Cholera and Enteric may be caused by impure water there is ample evidence to prove; in most instances the water was polluted with fæcal discharges.

Goitre is supposed to be produced by a deficiency of Iodine in the drinking water. Some authorities believe the disease to be of bacterial origin.

Ova of parasitic worms are frequently found in water and may gain access to the stomach in this way. The more common forms are Bilharzia Hæmatobia, Ascaris Lumbricoides, Oxyuris Vermicularis, Filaria Medinensis, Distoma Hepaticum, Ankylostoma Duodenale.

(1) Bilharzia Hæmatobia or Schistosomum Hæmatobium. This trematode gains access to the human system through drinking water, or by its miracidia, from the evacuated eggs, penetrating through the skin of man while in the process of bathing. It lives in man in the portal vein and its branches and is distributed to the veins of the abdomen, particularly those of the pelvis or bladder and rectum. The manifestation of the disease, most frequently, is in the bladder, where at first there is catarrh, followed by sanguinous urine or hæmaturia.

(2) Ascaris Lumbricoides, or the round worm, sometimes enters the system through drinking water infected with its eggs.

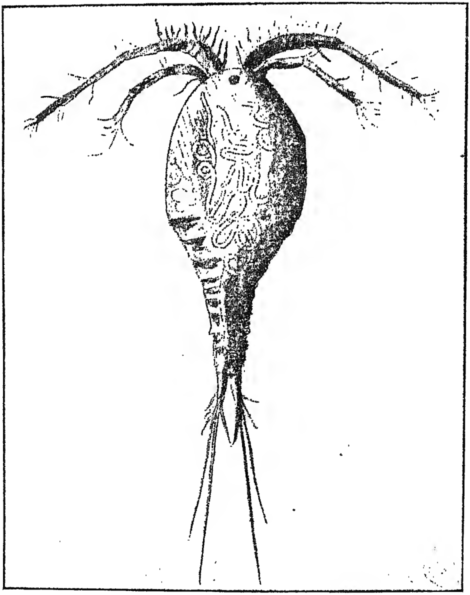
At Moulmein in Burmah during the wet season, especially at its commencement, natives and Europeans, both sexes and all ages, were in former years so affected by lumbrici as almost to constitute an epidemic. The only circumstance common to all classes was that the drinking water, drawn chiefly from shallow wells, was greatly contaminated by the substances washed in by the floods of the excessive monsoon" (Notter and Firth). The normal habitat of this worm is the small intestine. It however wanders all over the alimentary tract, and may be discharged by vomiting or by the stools. The ova of this worm develop in water or moist earth, after a long period of incubation. In medium temperature it takes about 30 to 40 days for the embryo to become formed. The spirally rolled up embryo never leaves the egg shell in the open. In this condition it gains access to the intestine of man and takes about 4 to 5 weeks to develop into young worms. The infection occurs partly through water but principally direct from the soil.

(3) Oxyuris Vermularis or the thread worm, is one of the most frequent and widely spread parasites of man. It occurs principally in children and its normal habitat is the large intestine. There the male and female oxyuris live and reproduce. The male rapidly dies and disappears, and that is why it is rarely met with in the excrement. The female remains very active and often leaves the tract through the anus and causes very troublesome itching. The ova also pass out and may infest man through water or be transferred directly from person to person by the hand and re-introduced into man *per os*.

(4) Guineaworm or Filaria Medinensis is very common in tropical climates. It was known to the ancient Arabs, and is most prevalent in Medina (Arabia), Persia, Turkestan and India. The Medina worm is widely distributed in Africa and is identical with what is generally known as guinea-worm. In adult stage it lives beneath the surface of the body, most frequently under the skin, in the lower extremities, chiefly about the ankles. It may also occur in other parts of the body. The male worm is very small and generally dies after attaining maturity. It is the female worm that burrows under the skin. When the worm tries to come out, a blister forms on the skin; this blister soon bursts leaving a superficial ulcer with a central depression through which the head of the worm protrudes.

When the ulcer comes into contact with cold—and this happens when an affected individual walks into the water of a steep-well or bathes in

it—the worm discharges her embryos, into the water. Dr. Max Braun, in his book "Animal Parasites of Man," says "it was known since the most remote period. 'The fiery serpents' that molested the Israelites by the Red Sea and which Moses mentioned were probably filariæ." The larvæ of the worm reach the open after the bursting of the mother's body. They live in water and moist soil. The larvæ enter the body of a cyclop through its integuments and there undergo development and are thus taken in with drinking water. When such infected cyclops are swallowed by human beings through their drinking water, the gastric juice kills the cyclops and liberates the contained embryos which are at this time 1-50th of an inch in length. Their further life-history in man is not known until about a year afterwards when we find them fully matured and with a length of from 2 to 3 feet; they are then ready to make their appearance on the surface of some part of the human body.



CYCLOPS QUADRICORNIS (AFTER LEUCKART).

The guineaworm disease, although it does not endanger life, is still productive of much suffering and is sometimes the cause of permanent deformities.

The prevention of the disease is a very simple affair. It is only necessary to prevent the embryos from entering the drinking water, and this can be done by not allowing any infected persons to have access to the well water reserved for drinking purposes. But the habits of the people and their general indifference in this respect make this an extremely difficult matter. Children and even grown-up people often jump into these wells for a swim or for bathing purposes and infect the water.

Straining the drinking water through fine muslin will keep back all cyclops and prevent the disease; but this must always be done.

Boiling the water will also kill the cyclops and prevent infection.

They can also be destroyed by treating the water with chlorine and copper sulphate together.

A type of fish named Barbus puckeltre, also destroys cyclops.

The best measure and the one certain to give the most permanent result is to cover up the well and draw the water through a pump.

(5) *Distoma Hepaticum*, or the liver fluke, inhabits the bile ducts of numerous herbivorous animals, chiefly sheep, ox, goat, buffalo and horse. It occurs equally in all climates. In India it is chiefly found in the liver of the buffalo and in Burma in that of sheep. In the latter animal it produces a disease known as 'sheep rot.' Its habitat is the liver which it gradually atrophies. The eggs of liver-flukes develop in water and the larvæ miracidia penetrate into a water-snail common in fresh water and become sporocysts, and these are further developed into young redia which become encysted on the meadows and are taken up by herbivorous animals with their food. The liver fluke is extremely rare in man: only 23 cases have so far been observed. It feeds on blood.

(6) *Ankylostoma Duodenale*—For this see p. 745.

PURIFICATION OF WATER.

The purification of water may be necessary in order to remove excessive hardness, suspended mineral or vegetable matters, dissolved organic matter, or for the removal or reduction of the number of micro-organisms.

Various methods are employed, *e.g.*, distillation, boiling, chemical agents, storage, filtration and application of ultra-violet rays.

DISTILLATION.

Distillation unquestionably produces a very pure water which is soft. It is only rarely employed on land but is frequently applicable at sea. Its use as a means of purifying water on land is obviously restricted to comparatively small demands owing to the expense involved. Distilled water is often flat and dull owing to loss of dissolved gases. In hot countries it has indifferent storage qualities. The lack of aeration can be partially remedied by passing the water through a clean sieve or by pouring in from one vessel to another, 2 or 3 times repeated, or by charging it with CO_2 gas under pressure.

As the first portion of the distillate contains a large amount of volatile impurities, and the last portion also is contaminated with volatile matter from the reactions of the concentrated solution of the mineral and organic matter, standard distilled water includes only the middle run of the still, the first and last portions being rejected.

BOILING.

All vegetative forms of bacteria are killed by boiling. Those bacteria which form endogenous spores withstand, of course, for the most part, the process of boiling.

The pathogenic varieties coming mainly into consideration, Cholera and Typhoid, form no such spores, and consequently boiling forms a safeguard against those diseases.

Boiling is limited to the purification of water in small quantities.

The chief objections to this method of purification are the expense involved, the water is rendered flat and insipid and the difficulty of getting the purified water in a cool state.

Besides killing vegetative bacteria, boiling also lessens the hardness of water; on the other hand, it does not remove any suspended matter. To overcome the difficulty of cooling the water, special apparatus in a variety of designs

has been invented on the heat exchange principle. By this, use is made of the fact that, with a sufficient area of metallic surface of good conducting capacity and sufficient time, a given quantity of hot liquid will yield nearly all its heat to an equal amount of cold liquid of similar nature.

By adopting this principle, large quantities of water can be rapidly treated and as rapidly cooled. The majority bring the water to the boil and depend on the expansion of the boiling water for the maintenance of the circulation of the water through the machine.

Many patterns exist, and the one in general use in the army is the Griffith which is capable of sterilizing considerable quantities (350 gallons per hour), with the expenditure of a small amount of fuel.

For drinking water for domestic purposes, boiling forms a certain method of killing most germs ; and has the advantage of requiring no special apparatus.

If, however, larger quantities are required, *e.g.*, for hospitals, schools, factories, mineral water works, ships, armies, etc., some special apparatus is necessary.

In the absence of any efficient means of sterilizing water by boiling, distillation or filtration, it may be necessary to fall back on chemical methods.

CHEMICAL METHODS.

(1) *Alum* is very frequently used to purify water of suspended matters. It has very good effect in clarifying water, specially if calcium carbonate be present. This forms calcium sulphate and aluminium hydrate, the latter forming a bulky precipitate which sinks to the bottom, bringing down a certain number of organisms with it. Alum does not act well if the water is very soft ; consequently, when such is the case, a little calcium chloride and sodium carbonate should first be added.

In all cases the alum should be well stirred up in the water and the mixture then set aside to allow the suspended matter to subside.

(2) *Potassium Permanganate* is of great use in cases where the water is impure and foul smelling.

It forms a precipitate of manganic oxide and carries down suspended matters. Some organic matter, both animal and vegetable is oxidised. A solution of the crystals should be made before adding the chemical to the water.

It is advisable to supplement the potassium permanganate treatment by alum purification and if possible filtration may be added.

If the water is very soft, add calcium chloride and sodium carbonate. No definite quantity of permanganate is used the custom being to add sufficient solution to make the water pink and retain its pink colour for about $\frac{1}{2}$ hour.

(3) *Sodium Bisulphate.*—Rideal and Parkes suggest the use of sodium bisulphate in the proportion of 15 grains to one pint. It causes a somewhat acid taste in the water but Cholera vibrios and the Enteric and Dysentery bacilli are killed by $\frac{1}{2}$ hour's contact.

Notter and Firth have devised a tabloid containing 2 grammes of 70 per cent. bisulphate sweetened with saccharine and flavoured with oil of lemon. One tabloid for every $1\frac{3}{4}$ pints of water sterilises the water in 20 minutes.

(4) *Calcium Hypochlorite (Chlorinated Lime—Bleaching Powder).*—It has been extensively used since 1908 to disinfect water, and specially during the war for the purification of water for the troops. It has a very useful field of application in emergencies on a small scale as for military use, and on journeys. On a large scale however it is being gradually replaced by liquified gaseous chlorine.

Calcium Hypochlorite is a whitish powder in friable lumps, with a feeble smell of chlorine, and a disagreeable bitter taste. It is alkaline in reaction and in solution bleaches litmus paper. It is liable to absorb moisture from the air specially in the Tropics and get damp, when it deteriorates and is converted into the more stable and inert

chlorides. It should therefore be preserved in air-tight barrels or tins out of contact with the air and the correct amount of available chlorine estimated everytime before use. It has been found however that the addition of 20 per cent. quicklime will show very little diminution in the chlorine content even after long storage.

Chemically it is expressed by the formula $Ca(OCl)_2$. The strength of a bleaching powder solution is usually expressed in terms of available chlorine,—that is the amount of chlorine readily liberated from its combination by the usual method of titration with Sodium Thiosulphate. A good sample of Bleaching powder should show an available chlorine of 35 per cent.

The action of the bleaching powder is as follows :—

$$Ca\ (ClO)_2 + CO_2 + H_2O = Ca\ CO_3 + 2\ HClO$$
$$2\ HClO = 2\ HCl + O_2.$$

The amount of chlorinated lime necessary to be added to a water will depend on the composition of the water. The presence of much organic matter will necessitate the addition of a higher dose, as much of it will be used up in oxidising the organic matter before it can perform its germicidal action. In the presence of much turbidity or organic matter it is preferable to filter the water before chlorination as the use of an excess of hypochlorite solution might impart a disagreeable taste to the water. The dose of chlorine required will vary according to the purity of the water from 0·25 to 1·0 part per million.

The treatment of water with chlorinated lime on a large scale is being superseded by liquified chlorine as it requires skilled supervision to avoid disappointing results. Moreover the plant presents an unsightly appearance and there is great difficulty of getting rid of the excessive amount of sludge which amounts to one gallon for every five pounds of chlorinated lime used. The plant necessary consists of mixing tanks, storage tanks and balancing tanks of galvanised

iron painted with some resistant paint, or of cement concrete. The solution of the hypochlorite solution is effected in the mixing tanks, and then led into the storage tanks whence the clear solution is used to sterilise the water, there being various mechanical arrangements to control the doses according to the volume of water and the strength of available chlorine.

METHOD OF USE (*Thresh*).

(*a*) Obtain a supply of good quality chlorinated lime in $\frac{1}{4}$ lb. sealed tins. Add the contents of a tin to one gallon of water and shake until uniformly mixed.

(*b*) A gallon of this mixture will now sterilize 8,000 gallons of any ordinary clear well or river water in 15 minutes.

(*c*) Obtain also, a corresponding supply of $\frac{1}{2}$ lb. packets of sodium hypo-sulphate, which is nearly tasteless and combines with all the available chlorine in half its weight of chlorinated lime.

Add one packet of this hypo-sulphate to one gallon of water and shake until dissolved.

(*d*) At the expiration of the treatment of the water with hypochlorite for 15 minutes, the gallon of hypo-sulphate solution is added and the excess of chlorine is thereby removed.

In encampments the water would require to be sterilized in the water carts and these vary in size usually from 100 to 150 gallons.

As one gallon of the chlorine solution mentioned above is sufficient for 8,000 gallons of water, one fluid oz. would suffice for 50 gallons. This being remembered, the quantity to be added can readily be calculated. Waters containing organic matter, such as peaty moorland waters, require more chlorine.

(5) *Chloramines*.—Hypochlorites in contact with ammonia and amino acids form Chloramines (NH_2 Cl) which have high germicidal power. They are apparently produced in small quantities in waters submitted to chlorination. Dakin has shown that antiseptic action of hypochlorites depends not on their oxidizing properties but on the action of chlorine on proteins or amino-acids producing chloramine compounds. Of the more important chloramines now used for disinfecting purposes are :—Chloramine T, Dichloramine T, Chlorizine, and Halazone. Halazone, a white powder, which is a relatively stable compound of benzoic acid with Chloramine T, has found extended application for field water sterilization. It destroys typhoid bacilli in 30 minutes in dilution of 1 part to 3,000,000 of water.

(6) *Chlorination*.—The chlorination of water can be effected by means of gaseous chlorine, or combined chlorine in the form of a liquid or solid. Gaseous chlorine is chlorine gas liquified under pressure and contained in steel cylinders with specially contrived exit valves, there being no action on the metal as the chlorine is in an anhydrous state. The combined chlorine include various solutions of chlorine prepared electrolytically such as the alkaline hypochlorite solution sold under the name of chloros, and the solid hypochlorite of lime (Bleaching Powder) which contains about 35 per cent. of available chlorine.

CHLORINE GAS.

Chlorine gas is obtained by the electrolytic decomposition of salt solutions, the gas after being dried is liquified under pressure in steel cylinders, each containing about 60 lbs. of the liquified chlorine, and also in drums or tank wagons when large quantities are required. The best storage is a cool dry place away from the direct heat of the sun and away from steam pipes and boilers. When the cylinders are empty the valves should be closed to prevent moisture entering into the cylinders.

In certain types of apparatus the dry chlorine gas is led directly from the control mechanism into the water main or aqueduct. This method is open to grave objections as a strong local solution may be formed under the crown of the pipe and cause corrosion of the water main. The usual practice now is to dissolve the gas in a certain quantity of water and introduce the resulting chlorine solution into the main. A certain volume of the chlorine gas is dissolved in a tank with a known volume of water and a strong solution of Cl is then soon made up, the gas, owing to its high solubility, being quickly absorbed.

For regulating, measuring and dispensing the chlorine gas, the Paterson Engineering Co. have invented the Chlorонome which has the necessary pressure reading, flow control and metering arrangements, with a moisture seal for preventing corrosion of the metallic parts, and an absorption tower wherein the gas is converted into an aqueous solution. Chlorination plants should always be installed in duplicate to provide against accident or emergency.

Since 1912 the use of Cl gas for the sterilisation of water has been extensively practised all over the world and has proved to be both efficient and economical. Its advantages are that the cost is very cheap, cheaper than bleaching powder and alkaline hypochlorite, and the dosage can be suitably regulated. The apparatus used is a compact one, Cl gas is easily available in a pure state and does not deteriorate on keeping, and chlorination dispenses in many cases with the expenditure of vast sums of money over large construction works for filtration, and pumping charges for storage reservoirs.

Chlorination of the water must not be considered as a substitute for storage and filtration but rather an auxiliary process, which supplements the effects of the filtration. A water which is grossly contaminated, and charged with large amount of turbidity and organic matter, *algae*, etc., would

require a large dose of chlorine to sterilize it completely and consequently the water would acquire a taste due to chlorine.

It is always preferable to chlorinate the water after filtration rather than before but in case when the construction of the water-works are such that it is only possible to chlorinate the water before filtration, care has to be taken to avoid any free chlorine from reaching the filters and destroying the natural purifying agencies at work in the filter bed.

The quantity of Cl usually added varies in practice from 0·25 to 1·0 parts per million depending on the amount of organic matter present in the water.

Houston recommends, in certain cases specially when time of contact with a normal dose of chlorine is not sufficiently long to effect complete sterilization, the process of superchlorination and dechlorination.

In superchlorination a much higher dose of Cl than is actually required is used to ensure rapid sterilization but it is only allowed to act for a short time, and the excess of chlorine removed by dechlorination.

It is important, however, that the chlorine should complete its work before the dechlorinator is applied as the sterilizing action ceases immediately after the use of the latter.

The principal dechlorinators are Sulphurous Acid Gas Sodium Sulphate, Bisulphate and Thiosulphate. Sulphurous acid gas is supplied in cylinders like Cl and it is measured and administered by an apparatus exactly like the Chloronome.

The other chemicals are solids and are used in the form of solutions at the required points, suitable measuring apparatus being used.

There are three main objections to chlorination of water :—

(*a*) Many people object to the use of chemicals for the purification of water and dislike drinking what they call a "doped water", but there is

absolutely no convincing proof that chlorinated water is injurious to health.

(b) On account of the great success of Chlorine treatment, Sanitarians are apt to neglect other purification methods and resort to mere chlorination as a "short cut" to purity in case of water supplies where filtration is necessary in addition to chlorination. Either on account of a breakdown in the chlorination plant, or neglect in giving the proper dosage, at a critical time when the water supply is perchance charged with pathogenic bacteria, a serious epidemic of Cholera or Typhoid may originate from a contaminated water supply.

(c) The third objection to chlorination is the unpleasant taste imparted to the water by an incorrect dosage.

TASTES IN CHLORINATED WATER.

Houston in his 18th Annual Report to the Metropolitan Water Board discusses at length the genesis and the remedy for the different tastes imparted to water by chlorination.

There are three fairly distinct tastes imparted to the water (a) chlorinous; (b) iodoform; (c) indeterminate tastes by the action of chlorine.

(a) A chlorinous taste is simply a taste of chlorine and not a secondary one produced by the action of the latter on other substances. It is due to an excess of chlorine and increases with greater dosage. It is not removed by Pot. Permanganate which actually makes it more pronounced. The only treatment is dechlorination.

(b) The Iodoform—or chemist-shop flavour is due not to excess of chlorine but rather to a small dose of chlorine. It is produced by the action of chlorine on other substances, probably of a phenoloid character. Water containing very little oxidisable matter appears to be specially sensitive so that it cannot be said to be due to the action of Cl. on organic matters. There is some constituent in the atmosphere at certain times and at certain places, probably of a phenoloid nature, derived from gas-works which combines with the Cl. and produces this taste. It does not take place if the water is not exposed to the air.

There is no taste to the water at the water-works but sometimes genuine complaints are received from people living at distant places that the tap water tastes badly though there is no free chlorine in the tap water. The coating of the pipes through which the water passes may

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contain some phenoloid body which combines with the Cl., and produces some "tasty" compounds.

Dechlorination has no effect on the Iodoform taste but Pot. Permanganate (1 in 5 millions) prevents the formation of the iodoform taste and removes it when found. So it is both a taste preventer and taste remover.

(c) The Indeterminate tastes are the earthy, bricky, mouldy tastes often imparted to chlorinated water which are also obtained in untreated water.

(7) *Iodine.*—Vaillard's red, white and blue tablets form a valuable method of rendering water safe in districts, where no other form of protection is available. The red tablet consists of tartaric acid (0·1 gm.), the white of sodium hyposulphate (0·12 gm.) and the blue of potassium (0·1 gm.) and sodium iodide (0·016 gm.). Method of use:—For one litre of water dissolve one red and one blue tablet in 2 or 3 tablespoons of cold water and add this solution to the litre of water, shake and mix well. The water becomes yellow due to free iodine. After 10 minutes, add one white tablet when, as a result, the water becomes colourless, due to the formation of iodide. The amount of iodine liberated in the above process is 60 m.m., and iodine in the strength of 25 m.m. per litre of water will kill with certainty the bacillus of Typhoid, the B. Coli communis and the Cholera vibrio in from 5 to 10 minutes. It is essential that the operation be carried out as above described.

PURIFICATION OF WATER BY OZONE.

Ozone, the so-called active oxygen, which is formed from the oxygen of the air by the silent discharge of high tension electricity through perfectly dry air, has proved to be a good medium for sterilizing water. When dissolved in water it kills the greater part of the bacteria and then escapes again from the water, without influencing the taste or smell, since it decomposes to ordinary oxygen. Many designs of plant have been proposed and used.

The general principle is that the water is treated with aluminium sulphate before entering the purification chamber and the air drawn into the ozone producer is first of all

dried by the use of calcium chloride or by refrigeration. After treatment with alum, the water is passed through mechanical filters. To the Petrograd water works is attached the actual ozone plant which consists of two parts, the ozone batteries and the sterilizer.

In the ozone batteries, the oxygen of the air is converted into ozone by high tension discharges. The concentration of ozone amounts to about 1 grain per cubic foot of ozonised air.

The movement of the air through the ozone batteries and pipes takes place by the aid of the so-called emulsifiers (Otto's system). These emulsifiers are water-jet air pumps, which by means of a water pressure of about 160 inches suck the ozonised air out of the ozone batteries and bring it mixed with water into the sterilizer.

The absorption of the ozone and the consequent sterilization of the water takes place partly in the emulsifiers placed near the sterilisers and partly in the agitators from the bottom of which the ozonised air rises to the top in a very fine state of division, and therefore in very intimate contact with the water. From the emulsifiers and sterilisers the water passes over a cascade to a pipe which leads it to a pure water reservoir, from whence it passes to the city main.

In order that the plant may work satisfactorily, it is necessary that the water to be sterilised contains no suspended matter and not too large an amount of organic matter, or ferrous oxide.

Where such are present, the ozone is in great part consumed in the oxidation of the dissolved substances or of the iron.

As a result of treatment with ozone the water undergoes an improvement in taste and colour, its chemical composition does not alter essentially, its temperature is not raised and

the ozone dissolved in the water disappears after 10 minutes. Bacteriologically, experiments made by many observers show that practically all bacteria, except the more resistant spores, are destroyed.

Chemically, according to Sanna, nitric acid is completely destroyed, and 15-43 per cent. of organic matter is oxidised. Ammonia present in the water is oxidised.

Sulphates, carbonates and chlorides are not affected.

Nitrates and free oxygen show an increase. Hydrogen peroxide is not formed. By using suitable amounts of ozone, complete sterilisation of the water takes place.

STERILISATION OF WATER BY THE ULTRA-VIOLET RAYS.

It is well known that if white light be analysed into its components by means of a prism, beyond the extreme violet end of the spectrum, there can be indicated certain rays which cannot be perceived as light rays, and are therefore invisible, but to which belong powerful chemical activities, *e.g.*, towards a photographic plate. That these ultra-violet rays also possess the power of killing bacteria has long been known.

Ultra-violet rays are to-day generated by means of the quartz mercury-vapour lamp.

An electric current is sent through the mercury-vapour which is enclosed in an evacuated quartz tube; the mercury vapour thereby glows and sends out ultra-violet rays which have the property of passing through quartz though they are absorbed by glass.

The lamp is contained in a cast iron cylinder divided into compartments, the water entering at one end and flowing in close proximity to the lamp. There are bafflers to agitate the water during its course and by an automatic device the circulation of water stops when the lamp goes out.

The lamp is immersed in the water so as to bring it in close contact and to enable the rays to be used up on all sides and also for the purpose of keeping the lamp cool.

In the more recent installations, an improvement has been effected whereby a small space intervenes between the lamp and the circulating water, whereby the amount of ultra-violet rays radiation is much greater than in the old apparatus in which the lamp was immersed in water.

Nogier in conjunction with Thevenot and Courmont made researches in the power of the ultra-violet rays emitted from a mercuric vapour electric lamp to sterilise drinking water. The earlier experiments showed that the rays have little penetrative power in non-limpid waters and that the presence of colloidal matters practically nullified the action. Further experiments showed that water which contained 100,000 B. Coli communis per c.c. was completely sterilised in one minute. A similar result followed double this number of B. Coli communis.

Typhoid Bacilli die in 10 to 20 seconds, Cholera Vibrios in 10 to 15 seconds, and resisting spores from 30 to 60 seconds.

Only clear water, without turbidity or colour, is sterilisable in this manner.

It was formerly thought that the action of the ultra-violet rays rested on the formation of hydrogen peroxide or ozone. Such is not the case however. Such compounds have never been shown to be present. The taste, smell, temperature and chemical properties of the water are in no way appreciably altered by the rays, and many experiments on animals have demonstrated the complete harmlessness of the waters so treated.

Many installations have been fitted abroad in houses, hotels, swimming baths, steamships, &c., but it has not been used on a large scale to a great extent as it is expensive and cannot compete with chlorination. It is not able to maintain a high efficiency if the physical characters of the surface water deteriorate, a time when the necessity of purification is much greater than in normal times.

STERILISATION BY CATADYN.

Catadyn, a recent invention, has been claimed to be a safe, economical and certain method of sterilising water. Investigations by scientists have to a great extent proved its great value in purifying water, but its real merit for use on a large and small scale will only be settled after some years of practical experience.

The word Catadyn is a contraction of "Catalytic-Dynamic" on which action the success of the process is supposed to depend. It was known for a long time that water stored in copper vessels acquired after some weeks germicidal properties. If such water was artificially infected with bacteria, they were killed. Instead of copper, metallic silver is used in catadyn, and it consists of highly active metallic silver fixed in a non-colloidal state upon suitable carriers usually in the forms of beads. When immersed into water very minute quantities of silver go into solution and form silver ions. The ions attract the oxygen dissolved in the water, and an "electrical tension" is set up between the silver ions and oxygen, and it is supposed that bacteria coming into these "tension fields" are killed off. The attraction of oxygen by silver is the catalytic, and the formation of silver ions is the dynamic action. Hence the origin of the word catadyn (Catalytic-dynamic action).

The loss of silver as determined by experiments is so infinitely small (about .000015 grm. per litre of water treated), that Catadyn will last for several years together. It is said that no ill effects can result from drinking large quantities of this water on account of the very small quantity of silver. The time of contact of catadyn needed may vary from a few seconds to a few minutes, and the catadynised water is not only itself sterile, but is highly charged with silver ions which render the water bactericidal and capable of sterilising raw infected water when it is mixed with it in varying proportions. Its bactericidal powers can be gauged from a report of the Haffkine Institute in which

the steriliser was capable of killing 3,000,000 B. Coli per c.c. and 5,000,000 B. Dysenteriæ per c.c.

The advantages claimed for Catadyn are its low cost, permanent service, minimum of attention required and no upkeep, no risk of over-dosage, and that the colour, taste, and smell of the water are not affected. It leaves the water richer in oxygen, and thus improves the taste of flat waters.

On a large scale, for the disinfection of the water supply of a town, it is claimed that the water can be led, during its course, into a tank containing Catadyn, the period of contact of the water with Catadyn being not more than a few seconds. Water thus treated would acquire bactericidal properties which would enable it to kill any bacteria which may subsequentally accidently contaminate the water in its transit to the places of distribution. In the case of turbid waters, previous filtration is necessary to prevent the deposition of the sediment on the silver, which would stop the action.

On a small scale for domestic purposes, or for travellers, sterilisers are obtainable as pitchers or boxes which contain the beads coated with metallic silver. The pitcher is filled up with ordinary water and kept standing for two hours; after which it is found to be sterile even if it had been previously heavily infected. Catadyn can be used not only for sterilising drinking water but for various other purposes, *e.g.*, washing fruits, salads, and other foodstuffs, dressing cuts, sores, wounds, and hands, cleaning plates, babies' bottles, swimming baths, etc.

Special Treatment of Peaty Waters.

Many peaty waters have a plumbo-solvent action and various devices have been adopted to overcome this difficulty. Previous reference has been made to this subject (see page 281). The following is the method adopted in Paignton. The water supply to this town comes from a moorland gathering ground on Dartmoor and,

though otherwise of good quality, it had formerly, in common with more or less all moorland waters, a very solvent action on lead. In 1909 special filters were installed, and continuous tests since made show that the water is now non-plumbo-solvent and fit for dietetic purposes. The special filters first remove from the waters the peaty solids in suspension, and afterwards render it non-plumbo-solvent by passing it through a chamber containing magnesium oxide, a material which has, after exhaustive trials, been found to be the most reliable substance yet discovered for destroying plumbo-solvency when used on the system of the Candy Filter Company of Westminster. Finally, the water is oxidised and purified by a layer of polarite (also contained within the filter) and then discharged into the clean water tank. Magnesium oxide, which is a hard granulated substance prepared by the Candy Filter Company, dissolves very slowly and in terms of hardness is more efficient than lime or chalk. The depth of the layer of magnesium oxide in the filter is in proportion to the acidity of the water and the filter is so arranged that, as the oxide is slowly taken up by the water, it can be replenished at intervals (once every week or two is sufficient) by a little more being added through a special charging door provided in the filter for such purpose. The filtered water was subjected to the usual chemical tests and showed free alkalinity with phenolphthalein, as compared with free acid with the untreated water, and 3 degrees of hardness in the treated water as compared with ·6 in the water direct from the impounding reservoir, thus satisfactorily indicating that the soft character of a mineral water may still be retained and yet the water be rendered non-plumbo-solvent by passing through the Candy special filter. The system is extremely simple and a distinct advance on the usual chemical processes for the removal of plumbo-solvency, as it entirely does away with the trouble, uncertainty and unreliability attendant upon the ordinary chemical and mixing

gauging appliances, machinery, small pumps, etc., and it has the great advantage of combining in one filter three different processes, *viz.*, straining, rendering non-plumbo-solvent, and filtering and oxidising the water.

Removal of Iron.

Certain waters may contain iron in greater or less quantities. When freshly drawn, the water may be quite clear but later it becomes turbid owing to the separation of a brown precipitate due to conversion, by the oxygen of the air, of the ferrous salt into an insoluble ferric hydroxide with evolution of carbon dioxide.

Although not really objectionable so much from the point of view of effect on health, it is so from that of appearance and on account of the deposit in the pipes and reservoirs. Three methods of removing the iron are used, based on the following principles :—

(*a*) By contact with air of the ferrous salt, the oxygen in the air oxidises this salt into an insoluble ferric salt. Consequently, the water may be well aerated and subsequently filtered.

(*b*) Since carbonic acid keeps the iron in solution, the precipitation of the iron may be effected by combination of the carbonic acid with lime.

(*c*) If the iron is present in the water in a colloidal form (organically combined), a coagulant such as aluminium sulphate or ferric chloride may be employed.

Removal of Manganese.

Manganese, like iron, can be removed by aeration, but it separates out with greater difficulty, since in the process of aeration some soluble manganese compounds form.

For the removal of manganese (and also of iron), Permutit (see page 280), has recently been recommended. It is a complex compound of sodium, aluminium and silicic acid,

occurring in nature. It is artificially produced by melting aluminium silicate with sodium carbonate.

It will remove lime, magnesia, manganese or iron from water when such water is slowly filtered through it.

REMOVAL OF FREE CARBONIC ACID.

If water contains much free carbonic acid, it may have a deleterious action on the concrete walls of storage reservoirs and on iron pipes. Three methods can be used for its removal :—

(*a*) The water is allowed to flow through limestone The free carbonic acid is thereby converted into calcium bicarbonate.

$Ca\ CO_3 + H_2\ O + CO_2 = Ca\ (HCO_3)_2$.

(*b*) Caustic soda or sodium carbonate is added to the water in calculated amount, according to the estimated amount of carbonic acid. The free carbonic acid is converted into a bicarbonate.

$CO_3 + H_2\ O + Na_2\ CO_3 = 2\ Na\ HCO_3$.

(*c*) Allow the water to rain down in a fine state of subdivision, or to trickle slowly over coke, glass or gravel.

The disadvantage of this system is that it increases the amount of oxygen in the water and this causes severe rusting of iron pipes.

INFLUENCE OF STORAGE OF WATER PRIOR TO FILTRATION.

The researches of Dr. Houston, Director of Water Examinations, Metropolitan Water Board, have demonstrated the great value of storage prior to filtration. In his third report to the Metropolitan Water Board, Dr. Houston states that adequately stored water is probably incapable of causing epidemic disease. He does not advocate supercession of filtration, but rather storage plus filtration, and in support of this view he advances what is termed the triple plea in favour of the safety of stored river water.

The three processes which make for the purification of water under storage conditions are chiefly (1) Sedimentation, (2) Equalisation and (3) Devitalisation.

(1) *Sedimentation.*—This *per se* is insufficient to produce the desired results, but settlement even for less than 24 hours has a considerable purifying effect.

(2) *Equalisation.*—If the water destined to be stored were, to begin with, of uniform composition and contained the organisms of water-borne disease in uniform distribution, no equalisation in the sense meant could take place. But, as judged by the usual chemical and bacteriological tests, the quality of a river water varies enormously from time to time; it therefore need scarcely be said that mere storage, on purely physical grounds, undoubtedly smooths over (levels as it were) abrupt fluctuations in its quality.

Moreover, even sewage polluted rivers do not uniformly, or of necessity, contain (in ascertainable numbers) the microbes usually associated with water-borne diseases (*e.g.*, Typhoid).

(3) *Devitalisation.*—This is a factor of supreme importance. The destruction of the microbes of epidemic disease in water is merely a question of time. It is known to vary with the temperature, and no doubt is also influenced by many other factors, such as the prevalence of competitive organisms or their products.

To secure the absolute elimination of these pathogenic bacteria, several weeks' storage may be required, but for all practical purposes provision for 30 days' real storage is ample, that is when dealing with sources of supply comparable to those of London. Strong confirmation of the beneficial effect of storage has lately been obtained by the experimental proof that "uncultivated" bacilli succumb in *raw* river water at a more rapid rate than their "cultivated" brethren. It is strikingly obvious from experiments that temperature is an important factor bearing on the vitality

of the Typhoid bacillus in river water, and the lower the temperature, within the limits stated, (0°C to 37°C), the longer does this bacillus show evidence of its existence or vitality. During the cold months, therefore, it is specially desirable that the water should be adequately stored antecedent to filtration.

SUMMARY OF THE CHIEF POINTS SHOWING THE ADVANTAGES ACCRUING FROM THE SIMPLE STORAGE OF RAW RIVER WATER.

(1) Storage reduces

(a) The number of bacteria of all sorts.

(b) The number of bacteria capable of growing on agar at blood heat.

(c) The number of bacteria, chiefly excremental bacteria, capable of growing on bile-salt medium at blood heat.

(d) The number of coli like microbes.

(e) The number of typical B. Coli.

(f) The amount of suspended matter, colour, ammoniacal nitrogen and oxygen absorbed from permanganate.

(g) The hardness.

(2) Storage alters certain initial ratios, *e.g.*,

(h) It reduces the number of typical B. Coli to a proportionately greater extent than it does the bacteria of all sorts.

(i) The colour results improve relatively to a greater extent than those yielded by the permanganate test.

(3) Storage if sufficiently prolonged, devitalises the microbes of water-borne diseases.

(4) Storage produces a marked levelling or equalising effect.

(5) An adequately stored water is to be regarded as a safe water.

(6) The use of stored water permits of a constant check being maintained on the safety of a water supply antecedent to and irrespective of filtration.

(7) The use of adequately stored water renders any accidental break-down in the filtering arrangements much less serious than might otherwise be the case.

While these are the advantages, there are certain real potential disadvantages.

(*j*) Sometimes algæ develop to such an extent in storage reservoirs as to interfere seriously with filtration processes and in some cases the water may acquire a fishy taste and odour. These troubles may be combated by the use of copper sulphate (2–10 lbs. per 1,000,000 gallons) under skilled supervision. In certain cases Houston found that the use of permanganate of potash ($2\frac{1}{2}$—5lbs. per 1,000,000 gallons) in the case of London's supply destroyed the taste in a few minutes. Such treatment, however, requires expert advice.

The results observed in connection with the storage of London water quoted by Houston must not be read as necessarily applicable to cases in general, especially if climatic conditions are not comparable.

Experiments conducted by Colonel Clemesha prove that within a period of 8 days the beneficial effects of water storage become evident. Experiments made in Madras to distinguish between the effect of storage alone, and storage in combination with sunlight, have proved that during the first 4 days of storage there is a very considerable and rapid diminution in the number of bacteria, the maximum reduction reaching about the 8th day. There was similarly a great reduction in the number of lactose fermenters. There was no consistent difference between the combined action of storage and sunlight and storage alone. It would appear that under tropical conditions storage for a short period of 5 to 8 days has beneficial effects.

THE FILTRATION OF WATER.

This must be considered from two points—whether the filtration is required on a small or a large scale.

DOMESTIC FILTRATION.

There are two systems of domestic filtration, *viz.*, the low and the high pressure system. In the latter, the filter is directly attached to the water pipe and the pressure is derived from the main. In the former the pressure is merely that derived from the water lying on the filter bed.

The best high pressure filters are the Pasteur-Chamberland and the Berkefeld.

The Pasteur-Chamberland consists of a candle or cylinder of fine grained unglazed porcelain enclosed in a metal jacket. The cylinder is closed above and terminates below in a nozzle. Between it and the metal jacket there is a space both above and on all sides. The water under pressure from the main enters the metal jacket and circulates round the cylinder and passes from without into the interior of the candle to be delivered *via* the nozzle as purified water. The rate of filtration depends on the pressure.

The Berkefeld is somewhat similar in design. The candle is composed of compressed infusorial earth. It is thicker but at the same time more porous and much more liable to fracture than the Pasteur-Chamberland.

After prolonged use, the filtering capacity of both types becomes much lessened and the filtrate ceases to be so good in quality. The former is due to the clogging of the filter by suspended matters arrested on the surface and the latter to organisms growing through the filter.

The cylinders should be periodically cleansed (every 3rd day) by brushing them in hot water and subsequently sterilising them in boiling water.

Clarification of the water prior to filtration greatly prolongs the life of the candles.

It should, perhaps, be unnecessary to state that the development of the slightest crack in the candles renders them useless as filters; yet one often sees cracked candles in use. This point should always be carefully attended to and one must always remember that the candles require careful handling.

The water pressure should not be more than one or two atmospheres, and should not act jerkily, since such pressure assists the passage of bacteria through the filter.

Slow Filtration without Pressure from the Main.

Of recent years the Berkefeld and other companies have placed such filters on the market. They require most careful attention to cleanliness and the preliminary use of coagulants if the water is at all muddy.

The number of different forms of domestic filters is legion. They are all based on the filtration of the water through some porous material, with or without the employment of increased pressure. Many old pattern filters are still sold, the majority of which are more or less useless.

For example, the old carbon filter; which is composed of plastic retort carbon or finely sieved charcoal. The charcoal filter oxidises organic matter but does not sterilise the water but rather favours the growth of bacteria by adding nitrates to the water as well as phosphates, both of which act as nutrient media. It attacks putrefactive organic matter but allows fresh to pass. Also, as regards removal of turbidity, these filters are of little use.

Stone Filters of Sandstone, Pumice, etc.

The stone is burnt from coarse or fine sand, quartz, lime, and magnesium silicates. The clarification of the water may be rather good, but the bacteria pass through fairly readily, at the latest after 2 or 3 days.

They are slow in action (1 litre per hour) and even this yield falls off rapidly.

Asbestos of very fine fibre is used, as a pulp, or compressed or mixed with other materials. They retain bacteria fairly well, but choke up very quickly and this necessitates frequent cleansing and sterilisation.

Polarite, magnetic carbide and spongy iron have all been used.

Filtration on a Large Scale.

The researches of Houston have shown that efficient storage and filtration are very intimately associated. The

objects of filtration are to remove turbidity, taste and odour, and to remove very fine suspended matter, low forms of animal and vegetable life and bacteria, and organic matter in solution—in fact to improve the water physically, biologically and chemically. Filtration on the large scale may be by the more usual slow sand process called also English filters or by the method so frequently seen in America—by the agency of mechanical filters. Sand is the most usual filtering medium and many experiments have been carried out to determine the best conditions under which such filters should work.

A slow sand filtration plant consists of several beds arranged in rows. Each bed is composed of a masonry tank, square or rectangular in shape, about 8 feet deep containing stone, gravel and sand, in varying proportions and progressive degrees of fineness from the bottom upwards. The layer of sand is usually 12 to 48 inches deep, the coarser sand being below and finer above. The sand rests on a stratified layer of gravel and stone which are graded in size, the larger being below and the smaller above, to prevent the sand from passing through to the underdrains. The gravel (coarser at the bottom than at the top) is about half a foot in depth and the layer of bricks and broken stones 6 inches deep. The bottom of the tank is sloped and underdrained to permit the clear water to flow away in the required direction. It is important that the underdrains should be properly constructed to ensure a uniform and not a varying rate of filtration throughout the bed. The bottom and sides must be perfectly water-tight to prevent leakage and the consequent loss of filtered water, and the entrance of polluted water from outside. Valves are provided at the inlet and outlet to regulate the flow of water on to and through the filters. At the inlet a cushion wall is provided to break the force of the flow of the water on to the filter and so permit its gentle passage on to the sand.

FACTORS TO BE CONSIDERED IN CONNECTION WITH SAND FILTERS.

(1) *Influence of depth of sand.*—Within certain limits the depth of sand exerts but little influence. The Massachusetts experiments showed that, with moderate rapidity of filtration, one foot of sand appeared as effective as five. The sand however should not be less than one foot in depth.

The usual depth of sand is 12 to 48 inches. A deeper sand layer has the effect of levelling any irregularities in the rate of the filtration and in producing a purer water.

(2) *Size of sand grains.*—The larger the size of the sand grains, the more quickly does the water pass through, but the coarser sand does not yield such pure germ-free water as does the finer.

There are, however, practical limitations preventing the use of too fine sand. If the sand is too fine, the rate of filtration is very slow, the filters soon clog and require frequent scraping; this is the case whether the filtration be continuous or intermittent—though filters used continuously require less frequent scraping than those used intermittently.

The sand may be obtained from the bed of a river or from sand banks. The sand must be washed to remove any clay present, and should not contain any lime as it might make the water slightly hard, and cause disintegration of the filtering material.

Hagen, in summing up a series of experiments, says:—Both the quality of the effluent and the cost of filtration depend on the size of the sand grains. With a fine sand, the sediment layer forms more quickly and the removal of bacteria is more complete but, on the other hand, the finer sand clogs more quickly and the dirty sand is more difficult to wash and the expense is thereby increased. With very fine sand, it is almost impossible to drive bacteria through and the filtrate is practically sterile but the rate

is too slow. With a coarse sand, the suspended matter including bacteria penetrates further and consequently thicker layers have to be removed. The minimum expense for cleansing will be secured with a sand which does not allow this deep penetration.

Thresh's specification for the effective size of sand is that the whole of the sand should be of such fineness that it will pass through a wire sieve having 400 meshes to the square inch, and 80 per cent. of it will pass through a sieve having 900 meshes to the square inch, and none of it through a sieve having 3,600 to the square inch.

Further, similarity of form in the size of the sand is important. The more dissimilar the particles of sand are, the more erratically the filter works.

(3) *Rate of filtration.*—Koch after many experiments came to the conclusion that the maximum rate of filtration should be fixed at 2,000,000 gallons per acre per day.

The more slowly filtration takes place, the purer, as a general rule, is the filtrate. The rate varies greatly in different water works but on average it amounts to about 4 inches (100 millimeters) per hour (*i.e.*, 60 gallons per square foot of surface per day).

The rate of filtration can be controlled by automatic devices or by the hand regulation of valves at the exit pipe of the purified water. It is essential that there should be a constant steady rate of flow and any sudden variations will be detrimental to the successful purification of the water.

(4) *Filtering agents.*—Water in passing through a sand filter is subjected to two processes: (*a*) mechanical and (*b*) chemical, as a result of which improvement in its quality is effected.

The chemical action is slight but a certain amount of oxidation of the organic matter present in the water does take place. This action is probably due to the presence of

nitrifying organisms in the sand itself as well as to the presence of air in the interstices of the sand. The mechanical process however is the more important. In this the substances which have not subsided, but remain suspended in the water, are kept back.

The real effective agent in removing organisms from the water undergoing filtration is the layer of gelatinous organic matter which forms on the surface known also as the "Vital layer" and if this surface be removed by scraping, or its continuity be affected in any way, the number of bacteria which pass through, increases. Frost, water rich in vegetable growths, insects, eels, too great a rush of water, etc., may cause loss of continuity of this surface layer, which consists of diatoms, green and blue algæ, bacteria, desmids and animalculæ.

Hagen states that in the winter it is chiefly diatoms, and in the spring green algæ appear, whereas blue algæ are more numerous in the hottest months continuing into autumn and disappearing in winter.

This layer is charged with microbial life, and it is by these organisms that the nitrification of organic matter is effected, and the whole layer assists in arresting microbes which may be present in the water. The continuity of this surface layer is essential to the efficiency of the filter.

Certain experiments carried out showed that over 80 per cent. of the bacteria removed by a sand filter were found in the upper inch of sand and 55 per cent. in the upper $\frac{1}{4}$ inch.

(5) *Frequency of scraping.*—After a certain period of time which varies according to circumstances, it is found that the output of a filter lessens considerably, in consequence of which it is necessary to put it out of action in order that it may be scraped and cleansed.

This is done by scraping away a thin layer of sand from the top of the filter, the amount removed varying in different works but on an average is about one inch. In some works,

after the removal of the top inch, the underlying sand is loosened to a depth of about 8 inches and the filter allowed to remain unused for a day or so to permit the access of fresh air.

The effect of scraping the filter to remove the clogged layer is to permit an increased number of organisms to pass through when the water is first turned on to the filter again. Consequently, after scraping, water should be allowed to stand on the filter bed for about 24 hours and the first water to pass through after that may be rejected. The object of this is to allow the filter to mature again.

The frequency of scraping depends on the character of the raw water, and on the size of the sand particles, the smaller the size the more frequently scraping being necessary. The rate of filtration and the maximum loss of head allowed also have an influence.

(The "head of water" is the difference of water level in the filter and in the pure water reservoir.)

A uniform discharge of water from the filter is most desirable, but as already stated, owing to the gradually increasing clogging of the filter, the velocity of discharge becomes lessened and the filter can be kept up to its work only by gradually increasing the "head of water." This is best done by diminishing the water pressure in the pure water reservoir rather than by increasing the amount of water in the filter.

Apart from scraping the surface, from time to time the sand must be replaced by fresh or washed sand. The filter is removed down to the layer of gravel, new sand is filled in and in some instances this is covered by a layer of the lower portion of the old sand which has a sticky nature and which accelerates the formation of the surface sediment layer.

The interval between scrapings must, as has been stated, vary largely from a few days to many months.

(6) *Sand washing.*—In London and Antwerp the sand is washed, on an inclined plane surrounded by a wall, by means

of a hose. The sand is kept to the upper part of the plane while the water and dirt flow off. In Germany it is washed in a revolving cylinder.

There are numerous other systems.

(7) *Depth of water on the Filters.*—In most European cities, the depth of water on the filters varies between 36 and 52 inches.

GENERAL REMARKS ON SAND FILTERS.

Filters are either covered or uncovered. Open filters have the disadvantage that during frosty weather cleansing is made more difficult, owing to the freezing of the moist sand.

Covered filters are far more costly, the gelatinous layer is formed much more slowly as it is composed in part of organisms containing chlorophyll and consequently needing light. On the other hand, in some instances this slower growth of algæ, etc., is not a disadvantage.

In countries abounding in mosquitoes, covered filters with mosquito-proof openings are desirable, and for this reason and to exclude the droppings of birds it is an advantage to have covered filters in India.

In order to permit the air in filters to pass out, so that it is not constrained to rise to the top, thus causing a disturbance of the filtering agents, tubes for the removal of air are let into the side walls.

In practice, the filters are frequently filled with water from below to just above the surface of the sand, then the impure water is allowed to flow in from above, and to remain at rest for a period of time during which the formation of their gelatinous layer is accelerated.

The filter is then allowed to work and the filtrate is allowed to flow away until the germ content has reached a certain limit.

Then the filtrate is permitted to pass into the clear water reservoir.

Each filter bed should have a separate contrivance to regulate the pace of filtration, each bed should be small, never exceeding one acre in extent, and it is most desirable that all filter beds should have separate filter wells for sampling purposes in order to see that the bed is working satisfactorily. It is not sufficient that the quality of the mixed filtered water is good; each of the units filtering should be in proven and perfect working order. The total area of filter beds required in any case is calculated from the quantity of water required for all purposes, the rate of filtration, plus an allowance for filters out of use for purposes of cleaning.

Investigations have been carried out at the King Institute, Guindy, since 1913, to discover the most efficient method of water filtration best suited to the conditions in the Madras Presidency.

The water was drawn from a river which, in the rainy season, shows countless organisms per c.c., lactose fermenters being present in .001 c.c., whereas, in the hot weather the total microbic count may be reduced to 4,000 per c.c., and lactose fermenters may be absent in less than .1 c.c.

Prior to filtration the water was subjected to storage for a short time so as to permit of sedimentation of suspended matter.

As a result of a large series of experiments with sand filters it was found that:

(1) the total bacterial count was reduced twelve-fold, the lactose fermenters being eliminated more readily;

(2) the length of life of a filter was 6 to 11 weeks, the maximum rate of filtration being 4 vertical inches per hour. It was noticed however that at intervals there was a sudden deterioration in the purity of the filtrate, due to breaks in the biological film covering the surface, caused by movements of frogs or aquatic insects, heavy rain, excessive growth of algæ, &c.

In order to obviate these disturbing causes, the filters were covered over so as to keep away animals and prevent other mechanical disturbances and it was found that when the filters were protected in this manner, the results were much more satisfactory than when the filters were uncovered.

(1) Bacteriological test showed that uncovered filters yielded a filtrate containing 250 to 400 microbes per c.c. whilst in the covered filters the filtrate contained only 50 to 90 microbes per c.c., there being in the latter case a still further reduction in the number of lactose fermenters—they being absent in 300 to 1,000 c.c. samples.

(2) The life of the filter was increased from 11 to 21 weeks, and the rate of filtration from 4 to 6 vertical inches per hour.

(3) The texture of the filtering skin in the covered filter was more uniform and not so thick as in the case of the uncovered one.

Numerous experiments have been tried to vary the thickness and texture of the various layers of the filter, compatibly with giving a sufficient support to the biological film. It was found that by placing flat tiles on the bond system in these layers between the coarse and fine sand, good results could be obtained with a thickness of 18 or even 12 inches of sand. The sand retained in a sieve containing 40 meshes to the inch proved to be the best.

As the biological film formed on the surface of the water was found to be independent of the amount of suspended matter in the water, the addition of alum to the water prior to sand filtration was attempted but the filters clogged rapidly and the results were not satisfactory.

As regards the relative merits of sand and "gravity mechanical filters," the conclusions are that the sand filters give far better results. Slow sand filters yield a purer filtrate than gravity mechanical filters and exert a special influence upon the lactose fermenters whereas mechanical filters show

no such action. The efficiency of gravity mechanical filters was variable as it depended on the condition of the raw water whereas in the case of the sand filters it did not so depend.

MECHANICAL OR RAPID FILTRATION ON A LARGE SCALE.

The general principles of mechanical filters are :—

(1) the addition of a coagulant like alum to the water and subsequent sedimentation.

(2) the filtration of the clarified water at a rapid rate through a tank containing a filtering medium.

(3) washing of the filtering medium periodically when it gets dirty by reversing the flow of water and agitating the medium.

Where turbid waters are treated, a coagulant such as alum is added to clarify the water before it passes through the filter. This assists in forming an artificial filter layer as it reacts with the alkaline earths present in the water.

$$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 = Al_2(OH)_6 + 3CaSO_4 + 6CO_2$$

Most of the flocculent, gelatinous aluminium hydroxide sinks to the bottom, and the suspended matter travels with it. The flakes still remaining in the water form a sediment layer on the filter (Tillmans).

The amount of alum necessary is 1 to 3 grains per gallon of water or 150 to 400 lbs. per million gallons. The amount of alum required depends on colour and turbidity of the water and varies with the alkalinity, temperature, and amount of CO_2 in the water.

There are a large number of different systems.

(1) *The Candy Filter* is a filter in which sand and polarite (a magnetic oxide of iron) form the filtering medium. A closed tank is divided into compartments containing polarite and sand. The unfiltered water enters under slight pressure and in doing so is sprayed so as to become charged with

compressed air. Each compartment of the cylinder is a separate filter. A considerable portion of the organic matter is oxidised and bacteria are removed. By occasionally reversing the current the suspended dirt which has been stopped by the filter is removed. The filter is successful in removing iron and lead from waters.

In this system no chemical coagulants are used.

(2) *The Jewell Mechanical Filter* consists of a steel cylinder containing the filter bed which is encased in a second cylinder of somewhat larger diameter, leaving an annular space between the two. This space is closed underneath, and into it comes the raw water which has been previously treated in sedimentation tanks and passes on to the filter bed which is composed of sand.

After passing through the sand, the water is collected in a series of tubes and passes thence to the pure water basin.

The rate of filtration through mechanical filter is about 100,000,000 gallons of water per acre per day and if properly designed and worked there will be 90 to 95 per cent. reduction of bacteria.

There is a regulator tokeep the rate of filtration constant. To clean the filter, filtered water is passed through in a reverse direction under pressure, the filter bed (sand) being well stirred at the same time so as to effect a thorough cleansing of the sand. It is claimed that these filters occupy only a small area of ground, they are easily and rapidly cleansed, and that objectionable growths cannot take place in the filters and there is less risk, therefore, of the water acquiring odour and taste. The sand can be easily sterilised if required.

Mechanical filters require skilled supervision to be worked satisfactorily as the quality of river water is liable to change from hour to hour, and day to day, and only constant examination will reveal the correct doses of the coagulant and ensure the proper control of the plant.

SLOW SAND FILTRATION *vs.* RAPID FILTRATION.

	Slow sand filtration.	*Rapid sand filtration.*
1.	Initial cost of outlay large; maintenance charges small.	Initial cost relatively small; maintenance expensive.
2.	Preliminary treatment not necessary but may be used in special cases.	A coagulant like alum must be added before filtration to produce sedimentation.
3.	Rate of filtration 2,000,000 gallons per acre per day.	Rate of filtration 100,000,000 gallons per acre per day.
4.	Large area of land required.	Much smaller area of land necessary.
5.	Advantageous for waters with little turbidity and not coloured.	Useful for waters which are highly turbid and coloured.
6.	Nitrogenous matter is oxidised during filtration.	No oxidation of nitrogenous matter.
7.	The process is partly a biological one effected by the "Vital Layer" and partly mechanical.	The process is mainly mechanical.
8.	When filters are clogged, the superficial layer of sand is scraped off not to overtax the filter and replaced by clean sand.	When clogged the sand is washed by reversing the flow of water and agitating the sand by compressed air.
9.	Reduction of Bacteria 99 per cent.	The reduction of bacteria is less uniform—about 90 to 99 per cent.
10.	Colouring matter in water little reduced.	Nearly all colouring matter removed.

SWIMMING BATHS.

Swimming has become increasingly popular, because it is one of the best and most exhilarating form of exercise specially suitable for the tropics. It promotes cleanliness and ensures the physical development of the body. Great care is required in the design and construction of a swimming bath and its efficient management. It is not merely necessary that the physical qualities like taste, appearances, and colour of the water should satisfy the æsthetic sense, but the water should be chemically and bacteriologically pure, or else

it may be a source of infection to the people. The diseases which bathers may contract through the use of impure swimming bath water are venereal and skin diseases, conjunctivitis, and inflammatory diseases of the upper respiratory tract, Otitis, Influenza, Diphtheria, Tuberculosis and Enteric Fever. It is necessary, therefore, that the water should be clean and pure, and that precautions should be taken to prevent certain people from bathing. Persons suffering from any infectious disease, skin diseases, sores, etc., should not be permitted to enter the bath. Every person prior to having a swim should have a full shower bath with soap as to cleanse his body. Ample toilet facilities should be available to avoid the possibility of people urinating while they are bathing. The towels and swimming suits should be disinfected before use.

Just as B. Coli is an index of pollution of drinking water, so also bath waters should be examined bacteriologically but the standard should not be so rigorous as for potable water.

The water of a swimming bath should be kept fairly clean by filtration, and rendered subsequently safe by disinfection with Chlorine, Ozone, Ultraviolet rays or Catadyn.

Paterson plant for the purification of swimming bath water embodies the following features:—

1. The continuous circulation of the water through the bath.
2. The removal of any coarse matter.
3. The additions of chemicals to coagulate the colloidal impurities and to remove any colour.
4. Filtration to remove the suspended matters and coagulated impurities.
5. Æration of the water.
6. Sterilisation with a very small dose of chlorine (1 part in 2,000,000 parts of water).
7. Reheating of water.

EXAMINATION OF WATER.

COLLECTION OF SAMPLES.

The collection of samples of water for chemical and bacteriological examination requires very great care if the results are to be relied upon.

For chemical examination the water may be collected in a Winchester quart bottle which has been thoroughly cleansed previously. Glass stoppers should be used for closing the vessel.

If for bacteriological examination, it is best to use a Pasteur's bulb which consists of a glass tube blown out at one end to a bulb and drawn out at the other end to a fine point. These bulbs are supplied perfectly sterile. They contain a partial vacuum and when about to be used they are held under water and the thin sealed drawn-out end is broken off, thus allowing the water to enter the tube. When the specimen has been obtained, the drawn-out end is again sealed by means of a spirit lamp and the bulb is replaced in the special metal case provided. In the absence of Pasteur's bulbs, water can be collected in a sterile 4 oz. bottle and put in a Horrock's box which has a special compartment for ice.

When taking a specimen from a hydrant or tap, the water may be allowed to run for a few minutes before taking the sample, unless in the case of the latter, the object is to test for lead. If from wells with pumps, the pump should be worked for a few minutes before taking the samples. In collecting samples from a tap or pump or hydrant, it must be remembered that the tap, etc., may be dirty and care should be taken to obviate this source of error.

If the sample is from a reservoir, then it should always be taken from the windward side and from not too near the bank. The bulb should be held well away from the bank by means of a rod, and it will be quite easy to fix up an arrangement to enable the sampler to break off the fine drawn-out end.

The bulb should be held below the surface so as to avoid the surface contaminations.

In taking a sample from a deep well, use a perfectly clean weighted bottle provided with an arrangement for pulling out the stopper when required. Under no circumstances should the stopper be removed from the bottle, or the fine drawn-out end of the bulb be broken except for the purpose of taking a sample. The part of the stopper which goes into the bottle and the drawn-out broken end of the bulb should not be touched by hand during the process of collecting the samples. Having obtained a sample, from whatever source, it is most important that no time be wasted and that the sample, packed in ice, be at once despatched to the analyst. The ice is to prevent undue multiplication of the organisms present.

Any delay in forwarding the sample may entirely vitiate the analysis and give an erroneous impression of the quality of the water.

It is most important that the whole operation should be conducted in such a manner as to exclude any possible extraneous contamination.

In the event of a supply of water becoming polluted, it may be necessary to examine the whole of the collecting ground in order to ascertain the source thereof. To do this, one must follow up each stream feeding the reservoir to the spring or moorland surface from which it is derived and apply the following test to each stream in succession. Obtain a sample at the source and also just at its entry into the reservoir and examine both bacteriologically and chemically; if the latter sample is found to be more impure and to contain organisms indicating sewage contamination, then follow up the stream and note all contributory streamlets and take samples just above and below the point of entrance of all such. In this manner one may ascertain the source of contamination. This method is possible only in the case of small streams.

Minute inquiry must also be made into any history of illness of any of the employees and others who have occasion to frequent the gathering ground.

Inspection must also be made to ascertain the presence or otherwise of small villages or isolated houses on the catchment area. If such be found, one must ascertain the method of conservancy adopted and where the liquid refuse matter is disposed off. Most frequently it is the nearest stream where also washing of clothes, &c., is carried out. This should be ascertained and samples taken from this stream and also from the lake or reservoir close to the point of entrance of the stream. One should also ascertain the kind and number of the animals kept by the villagers.

One cannot dogmatically state what should be the composition of a good drinking water or give an absolute value to the significance of any one analytical datum. The analysis must be considered as a whole and in relation to the source of the water.

SOURCES OF THE CHLORIDES.

The chlorine in a water is nearly all in the form of sodium chloride. An average of a series of examinations in England is as follows :—

Rain water contains .22 parts per 100,000, upland surface water, 1.10 parts per 100,000, spring water 2.5 parts and deep well water 5.0 parts per 100,000.

Rain water, especially that falling near the sea-coast, often contains chlorides. Certain geological formations may contain strata bearing chloride of calcium and soda. Alkali works and mines may contribute some, wells near the sea are often brackish, and finally they may be present as the result of admixture with liquid excreta of men and animals, as urine contains about 1 per cent. of chlorides. In considering, therefore, the significance of chlorides, these possible sources must be borne in mind. If they come from strata containing sodium and calcium chloride, the water

may be found alkaline from the presence of sodium carbonate, the oxidised organic matter may be absent or nearly so and often there is much sulphuric acid. These characteristics are common in deep well water. The amount present may vary considerably according to the strata, and it is necessary to know the amount normally present for such district, and any variation from this would indicate the need for a further investigation. When due to admixture with sea water, much magnesia and but little evidence of oxidised organic matter may be found ; examples of such are sometimes seen in wells sunk near the sea shore or tidal rivers. When present, due to recent contamination with sewage, they will generally be present in marked quantity but not necessarily so and there will probably be evidence of nitric and nitrous acids and ammonia and sometimes of phosphoric acid, and, if the contamination be recent, of oxidisable organic matter. A stream fouled by sewage may show different amounts of chlorine at different periods of the day. As a general rule, contamination of a water with sewage can never take place without increase of chlorides, unless it be by some gaseous emanations, or unless the normal amount of chlorides in that particular geological formation is very high, in which case admixture with contaminated surface water or sewage may cause an actual decrease in the percentage of the chlorides present. It must also be remembered that the presence of chlorides does not necessarily signify present pollution : the organic matter originally associated with them may have been completely oxidised and destroyed. Upland surface waters free from animal pollution rarely furnish more than one part per 100,000. Some pure waters show 4 to 5 parts per 100,000. Wanklyn is of opinion that when 5 to 10 grains per gallon are present there is reason to become suspicious. Thresh is of the opinion that more than 50 grains of salt per gallon is objectionable and that 70 grains should condemn it absolutely.

ORGANIC MATTER IN THE WATER.

The organic pollution in water may be of animal or vegetable origin. The former is due to sewage (fæces and urine) finding its way into water, and the latter to the decomposition of vegetable matter. As there is the possibility of pathogenic germs entering the water with the sewage, pollution of animal origin is much more dangerous than that of vegetable, and it is important therefore to learn not only the amount of any organic matter which is fouling the water, but also its nature, that is, whether it is due to animal or vegetable pollution.

Under suitable conditions of humidity and temperature of the air, organic matter is decomposed into simple compounds in various stages by processes of fermentation, putrefaction and slow oxidation. Organic matter comprises complex compounds containing C, H, N, O, S, and P. The ultimate product of decomposition are CO_2, H_2O, free Nitrogen, Nitrous and Nitric acids which combine with bases to form Nitrites and Nitrates, and odourous gases containing sulphur and phosphorus. As there are no ready made tests to distinguish between the products of animal and vegetable pollution the evolution of methods to distinguish between the two has taxed the skill of chemists and forms a very interesting study. The standard method which has evolved from the researches of several years goes under the name of Wanklyn, Chapman and Hall process, by which the free and saline ammonia and albuminoid ammonia are estimated. Besides these two estimations, the amounts of chlorides, nitrites, nitrates and oxygen absorbed are also taken into consideration in judging the purity of water, and an opinion can only be formed by comparing the relation the above figures bear to one another.

SALINE AND FREE AMMONIA..

Urea is one of the chief nitrogenous constitutents of urine and by the action of Micrococcus Ureae it is rapidly converted into saline ammonia thus :—

$$CO(NH_2)_2 + 2\,H_2O = (NH_4)_2CO_3.$$

The free and saline ammonia constitute therefore the ammonia which exists in solution in water, or combined with acids (nitric, carbonic, etc.) or in some easily decomposable form. For its estimation the water is distilled and the amount of ammonia estimated in the distillate by colorimetric methods. Special laboratory manuals may be consulted for the exact technique for the determination of the various values.

The exact significance of this is difficult to briefly discuss ; generally speaking, the ammonia found in river, spring and well water is derived from pollution by animal matter, but the mere presence of ammonia in a sample of water cannot be held to indicate contamination with either vegetable or animal organic matter. All rain waters nearly contain ammonia, the quantity being considerable near large towns, and especially in the first portion of a downpour. Many deep wells also contain ammonia, which is generally held to result from the reduction of nitrates and nitrites by ferruginous soils. The conclusions to be drawn from the amount estimated will be described later on after explaining the nature of albuminoid ammonia.

ALBUMINOID AMMONIA.

Albuminoid Ammonia does not exist as such in water but it is a purely laboratory product. After the free and saline ammonia has been distilled off from a water there still remains a certain amount of nitrogenous matter. When this water is treated with alkaline permanganate solution and distilled again, the latter oxidises the more complex organic matter, decomposing it into simpler compounds and ammonia is formed, which distills over and can be estimated. This new quota of ammonia therefore is derived from the decomposition of the more stable organic matter and goes under the name of albuminoid ammonia. The relative amounts of free ammonia and albuminoid ammonia are very important in judging the nature of a sample.

It is important to remember that vegetable pollution produces more albuminoid ammonia with practically no free ammonia, whereas animal pollution shows relatively larger amount of free ammonia than albuminoid ammonia.

Therefore, if there is no free ammonia, or practically very little (under .002 parts per 100,000) and much albuminoid ammonia (above 0.005 parts per 100,000), vegetable contamination is indicated and this opinion is strengthened if the figures for chlorides and nitrates are low. On the other hand if the free ammonia figure is very high (0.005 parts per 100,000 and above) and the albuminoid ammonia also above 0.005 parts per 100,000, with unduly high figure for Cl, and nitrates and nitrites, then animal pollution will be denoted.

At times very high free ammonia figures are obtained with practically no albuminoid ammonia (below 0.002 parts per 100,000). This is not due to animal pollution but to other causes, *e.g.*—

(*a*) the water might have passed through a stratum of soil containing ammonia salts.

(*b*) some iron dissolved in the water might have reduced nitrates in the soil to ammonia.

(*c*) rain water might have absorbed ammonia from the air.

(*d*) metal pipes, cement, etc., might have reduced well waters.

On the other hand the albuminoid ammonia may be very high (above 0.01 part per 100,000) and the free ammonia very low (below 0.001 part per 100,000) without there being any suspicion of animal pollution as many peaty waters which are safe for drinking purposes show such figures.

The purest water supplies yield either no albuminoid ammonia or more usually only a trace upto 0·002 parts per 100,000.

OXYGEN ABSORBED.

In the presence of organic matter, Pot. Permanganate under favourable conditions parts with its oxygen, and is reduced to hydrated Manganese Dioxide and loses its pink colour. The amount of oxygen absorbed by the organic matter by the water is therefore estimated from the amount of Potash Permanganate used up. This method was used for many years, before the Wanklyn process, to judge the purity of water from the amount of organic matter present. It had however several disadvantages *viz.* that besides organic matter it was capable of being reduced by other substances in water and that it would part with its oxygen as readily to the less dangerous vegetable matter as to the more dangerous organic pollution and it has no constant relation to the total organic matter. For this reason this test is not much relied upon but it is still used as an auxiliary test to supplement the information provided by the Wanklyn test.

The amount of oxygen required to oxidise the organic matter in safe waters will not in general exceed 0.1 part per 100,000, though here again the limit may be exceeded by upland surface waters in which organic matter of an innocuous nature may exist. A good well water does not often absorb more than 0.001 part per 100,000. Certain other substances absorb oxygen, *e.g.*, iron salts, sulphuretted hydrogen, and peaty upland waters. Slight variations in temperature, acidity, and alkalinity influence the readiness with which the permanganate parts with its oxygen. Tidy considers that in the first fifteen minutes the more or less easily oxidised animal matters are oxidised, while the oxidation of the vegetable organic matter does not take place for four hours or so. The ease of oxidation is not a very reliable index of the real amount of pollution present. The water must be regarded as suspicious, if within 15 minutes the amount absorbed exceeds 0.1 per 100,000 and in four hours if it exceeds 0.3 per 100,000, in both cases deduction being made for any nitrites or iron salts present. The

permanganate does not act upon any fatty substances, starch, sugar, gelatine, urea, hippuric acid or creatinine present.

NITROGEN IN WATER.

The nitrogen present may be in the form of free nitrogen, ammonia, nitrites, or nitrates or as organic matter.

NITRITES AND NITRATES.

Nitrogenous organic matter undergoing putrefaction produces ammonia, and this is oxidised into nitrous and nitric acids by organisms in the soil. These acids unite with the lime, soda, and potash present, displacing the carbonic acid. Some geological strata contain a considerable proportion of nitrates, but a large proportion is by no means so common as in the case of chlorides. A water may be free from unaltered animal and vegetable contamination, but may contain oxidised products derived therefrom, either as the result of remote contamination, or due to oxidation which has occurred in the soil intervening between the source of contamination and the source of the water. The nitrates are the chief of these, but much care must be exercised in drawing conclusions from the amount of nitrates present. They may at times be derived from the soil the contamination of which is very remote, and, on the other hand, in very bad waters the nitrates may be lessened as a result of the impurity, the organic matters present reducing these salts to a less oxidised form. Again, the amount present may be reduced by the fact that growing crops take up ammonia, nitrites and nitrates, and further it must be remembered that animal matter decomposing in the absence of air or of free oxygen, tends to destroy nitrates liberating nitrogen. The Rivers Pollution Committee found that animal organic matter produced much nitrites and nitrates and that vegetable matter produced but little, not being highly nitrogenous and decomposing but slowly. The coincidence of easily oxidised organic matter, of ammonia, and of chlorine in some quantity would point

towards contamination by animal organic matter. If the water shows the presence of nitrates, but of no nitrites, and of but very little ammonia, then either potassium, sodium or calcium nitrate is present, probably derived from soil impregnated with animal organic matter at some anterior date. Nitric acid is the ultimate state of the oxidation of nitrogenous organic matter, and when present it is always the result of pollution of the water itself or of the stratum. The process of nitrification is due to organisms. In some soils, especially sands and gravels and in ferruginous soils, the process goes on very rapidly and consequently one must never omit the test for nitrates, as otherwise organic pollution may be overlooked.

The presence of nitrites indicates the existence of organic matter undergoing a change. It may either be a stage in the oxidation of such matter, or a retrogression from nitric acid as a result of the latter having yielded up some of its oxygen. It is rare to find any of the higher forms of life in a water rich in nitrites, though bacteria may be abundant. The presence of nitrites in the water of shallow wells or rivers is always of grave significance. In deep wells nitrates may be reduced to nitrites, due to iron salts or other innocuous constituents of the soil and, as Thresh points out, nitrites may also be formed from nitrates by a metal, such as lead or iron forming the tube of the pump or the lining of the well. The presence of nitrites is always suspicious of sewage contamination, except when it is known that the water is of peaty origin.

As a general rule, water ought to contain not more than 0.5 per 100,000 of nitric nitrogen and no trace of nitrite. When the nitric nitrogen exceeds 1 part per 100,000 suspicion is certainly justified in those cases where the strata may be excluded as the source of the nitrates. The coincidence of easily oxidised organic matter, ammonia and chlorides would point to organic matter of animal origin and if nitrites are present, the contamination is probably of

recent origin. The presence of high nitrates in the absence of nitrites and a low quantity only of organic matter does not necessarily mean that the water is injurious, as unpolluted sub-soil water may give this analysis.

BACTERIOLOGICAL EXAMINATION.

This is of great value in ascertaining the suitability of a water for drinking purposes, and by it one can obtain data which give information not only as to existing conditions but from which deductions can be drawn as to recent harmful pollution. The object of a bacteriological examination is to ascertain the presence or absence of any organisms and, if present, to determine their number and whether they belong to the class of micro-organisms which, though harmful to man, are yet indicative of animal contamination, or whether they are of the class of actual disease-bearing organisms, *e.g.*, Cholera vibrio and Typhoid bacillus.

The detection of these latter in a public water-supply is a matter of some difficulty, and in many instances one has to rely on the evidence afforded by the presence of organisms usually associated with fæcal contamination, either human or animal. In reporting on a water analysis, the bacteriological and chemical results must be carefully considered in relation to one another. As it is only under exceptional circumstances that zymotic poisons gain entry to a water-supply without associated decrease of chemical purity in general, it will be found that a water thoroughly pure chemically will also be pure bacteriologically. On the other hand, a supply which gives bad results on chemical analysis should be condemned, as, if free from pathogenic organisms on any particular occasion, it must be held to be at least liable to contamination with these and must form a good medium for the growth and dissemination of bacteria. It is in the case of waters of intermediate purity that a bacteriological examination becomes of the greatest importance as though the amount of contamination may be such as to

produce only a small amount of chemical impurity, yet it may be sufficient to produce marked bacteriological impurity. In both chemical and bacteriological examinations, great assistance is afforded by a knowledge of the exact source of the water, and for this reason it should be an invariable custom to give full details when sending a sample for examination.

The covering letter should state—

(*a*) The date and the hour of taking the sample.

(*b*) Source of water, well, lake, spring, etc.

(*c*) Filtered or unfiltered.

(*d*) If from tap, pump, etc., how long the water was allowed to flow before taking the sample.

(*e*) If from a tap, whether it was direct from the house main or through a storage cistern. Nature of cistern.

(*f*) If from a well, state whether apparently properly constructed and protected, the distance away from nearest visible source of contamination. Also how the water is raised from the well.

If any authentic records of former analysis of water from the same source exist they should be furnished, as information may be gleaned from them as to any departure from the normal.

Various selective and enrichment methods have been recommended for isolating Typhoid Bacilli from water. After heavily infecting a water in the laboratory with Typhoid Bacilli the methods of isolation seem satisfactory, but in actual practice, water infected naturally contains a very small number of Typhoid Bacilli and the methods fail.

Recently, however, Wilson and Blair have devised a medium which has special selective properties for the growth of Bacilli Typhosus. On this medium B. Typhosus grows readily and forms flat black dry surface colonies and B. coli either does not grow at all or forms some colonies which are brownish, sticky and raised.

The principle of the method rests "(1) on the positive property of the B. Typhosus of being able to reduce a sulphite to a Sulphide in the presence of Glucose, (2) on the

inhibitory action on the growth of B. Coli of bismuth sulphite in the presence of a certain excess of sodium sulphite."

For further details the 23rd Annual Report to the Metropolitan Water Board by Sir A. Houston should be consulted.

As already stated, the isolation of pathogenic bacteria from water is frequently attended with the greatest difficulty, and water may be grossly polluted with sewage without any specific disease-germs being present at all. All sewage polluted water is however potentially dangerous, as there is the possibility of disease-germs appearing at any time. Bacteriologists have therefore mainly to rely on the detection and isolation of excretal and sewage organisms which though not dangerous in themselves are significant as indices of the probable presence of disease-germs. The three most frequently used indicator organisms for this purpose are "the B. Coli group, Streptococci, and Bacillus Enteritidis Sporogenes and closely allied Anærobic Bacteria" (Savage). A water supply however should be finally judged on a summation of verdicts (geological, geographical, physical, bacteriological and chemical). According to Savage, the conditions of a perfect bacterial indicator are—

(1) It should be abundant in the substances, for which its presence serves as an indicator.

(2) It should be absent, or at least relatively absent, from all other sources.

(3) It should be easily isolated and numerically estimated.

(4) Its characteristics should be definite and not liable to variation, whereby its distinctive characters might be impaired.

The three indicators referred to by Savage are extremely abundant in both human and animal excreta and in sewage.

As regards human excreta, the B. Coli group are present to the extent of 100 to 1,000 million or more per gramme. Streptococci are equally numerous, while about 1 million to 10 million B. Enteritidis Sporogenes are present per gramme.

These organisms also occur in immense numbers in the intestines of all the domestic animals and apparently of all mammals.

The B. Coli group has been found to be abundant in the excreta of many birds and fishes.

Dr. Houston has laid down the following requirements, which must be conformed to by any microbe indicator suggested as an indicator of pollution of water :—

(1) It must be superabundant in excremental matters.
(2) It must be absent, or present only in comparatively small numbers, in water free from undesirable pollution.
(3) It must be a decadent microbe when divorced from the animal body.

Throughout his observations, Dr. Houston has chosen the B. Coli test as the indicator of water pollution. The typical B. Coli recognised by him is one yielding gas in lactose cultures and indol in peptone water cultures, *i.e.*, lactose and indol.+.

Now B. Coli conforms to all the requirements mentioned above :—

(1) Since at a low estimate there are 100,000 B. Coli present per cubic centimetre of crude sewage, or 1,000,000 per gramme of human fæces.
(2) Of 1,331 samples of Kent deep well waters examined, 94 per cent. showed no B. Coli in 100 c.c., and
(3) B. Coli removed from the animal body and kept at 20°C. either in sea water or tap water dies usually in from 3 to 9 days. The B. Coli is a decadent microbe when divorced from the animal body ; hence its presence in a water in any number probably points to fairly recent pollution.

The term B. Coli Communis does not denote a single definite organism but it includes a considerable group of distinct forms which may be split up into various sub-types by biochemical tests. No two bacteriologists therefore use the term in the same sense. Savage suggests that the expression "excretal B. Coli" should be used for organisms giving all the following characteristics :—

(*a*) A short rounded bacillus.

(*b*) Translucent non-corrugated growth on gelatin slope.

(*c*) Non-liquefaction of gelatin (two weeks).

(*d*) Acid production in litmus milk with coagulation (within two weeks).

(*e*) Fermentation of lactose with production of acid and gas.

(*f*) Fermentation of glucose with production of acid and gas.

(*g*) Neutral red reaction (in glucose media).

(*h*) Production of indol in peptone water.

It is difficult to say where the line should be drawn. The different tests have not an equal value: some such as the fermentation of sugars, liquefaction of gelatin, and acid production in milk are typical and are very important, and negative results would exclude the organism isolated from being Bacillus Coli at all, whereas the presence of motility, indol reaction, the characteristic of gelatin surface colonies are subject to such great variations, that negative results under these heads would not lead to the significance of the organism being diminished on these grounds.

Hence it is that bacteriologists classify the Bacillus Coli into "typical" and "atypical" forms. Of late years there has been a growing feeling that such arbitrary definitions went either too far or not far enough. The whole group of lactose fermenters being characteristically of intestinal origin, it is clear that the whole class of such organisms should be absent from safe water supplies. The Colon group may therefore be for practical purposes described as including all aerobic non-sporing bacilli which produce acid and gas in dextrose and lactose media. As these organisms which ferment lactose, ferment dextrose as well, the tests may be still further curtailed to positive reaction in lactose fermenting medium. It is usual now in laboratory reports to indicate the presence of lactose fermenters in least dilution of water.

Clemesha has shown that most of the waters which have to be used in India are simply loaded with fæcal contami-

nation and expresses the opinion that a great deal of the pollution of surface waters is caused by excrement of animals, mostly cattle and goats, whereas in England the pollution that is most common in rivers has its origin in sewage from large towns which we know to be derived from man, and he considers this a difficulty in the way of accepting standards applicable to England as being equally suitable for India.

The great rivers of India differ in many important respects from those in England, the self-purification of the river water being the most important. In England the rivers which are the sources of supply of water are comparatively small streams, into which the sewage and effluents flow from the towns on the banks. The water therefore is largely polluted and has to be purified thoroughly before it is potable. The rapid current and the presence of very little sunlight make the natural self-purification of the water an impossibility. In India, on the other hand, the great rivers (the Ganges the Mahanudi, etc.) are several hundreds of miles long and the current is so extremely slow that the water takes a long period to drift from the source to the sea. The towns on the banks not having regular drainage system, very little of the sewage of the town goes into the river, and even this is diluted by the large quantity of water, and although along the banks there is always evidence of dangerous and deadly pollution, the climatic conditions are such that the sun's rays cause great amount of evaporation from the surface and cause self-purification of the water.

MacConkey, not being satisfied with the classification adopted by most bacteriologists of Colon bacilli into "typical" and "atypical" forms, and believing that the so-called "typical" B. Coli are a complex group including a considerable number of definite individual types, outlined a new classification of the lactose fermenting bacteria based on fermentative reactions of the rarer sugars. Using saccharose

and dulcite he first divided the lactose fermenters into four groups :—

(1) Ferments neither saccharose nor dulcite.
(2) „ dulcite but not saccharose.
(3) „ both dulcite and saccharose.
(4) „ saccharose but not dulcite.

Col. Clemesha, however, recommends proceeding further and by the use of the fermentation of adonite, inulin, dulcite and saccharose, the Voges and Proskauers reaction, the indol reaction, the motility test and, when possible, the liquefaction of gelatin test, splitting up the group of fæcal bacilli and studying the individual species as far as possible; and thus in time he anticipates that one may be able to assign a relative value as an indicator of pollution to each of these organisms.

Col. Clemesha finds both in human fæces and in cow-dung the prevailing types to be B. Coli, B. Grunthal, and B. Coscoroba, the three together usually making up 75 per cent. of all the lactose fermenting organisms present. A very interesting fact revealed by his investigations was the occurrence of "epidemics" of particular types which at certain periods become suddenly frequent, usually prevailing in human fæces, cow fæces, and water supplies at the same time. Clemesha made a number of experiments on the relative resistance of various lactose fermenters by placing fæcal emulsions, with or without sand, in shallow dishes in the sunlight and at various intervals isolating colonies of predominant types and working out their fermentative reactions. The experiments showed that B. Coli was the principal type isolated in the beginning, it quickly disappeared however and in a few hours B. Lactis Aerogenes, B. Acidi Lactici, B. Cloacæ, and others appeared. At the end of the experiments B. Grunthal or B. Cloacæ were generally the only forms surviving.

The moral drawn from Clemesha's investigations is that in India, in waters stored in warm sunned lakes and large rivers, as the sensitive fæcal bacilli have an opportunity to die out and the more resistant have an ample opportunity

of multiplying and increasing, it is not proper to condemn any water merely from the presence of the colon group without finding out whether it contains the sensitive or more resistant types. In view therefore of the natural process of self-purification going on in Indian lakes and rivers, the utter futility of hard and fast numerical standards of purity of waters is evident. The more one studies the self-purification of waters, the more certain one is that it is necessary to study the *kind of organisms* rather than their *number* in order to come to a satisfactory conclusion.

As the result of his experiments Clemesha has divided fæcal organisms into three classes according to their power to resist sunlight.

(1) The delicate organisms or those very susceptible to the action of sunlight, *e.g.*, B. Coli Communis and B. Oxytoccus Perniciosus.

(2) An intermediate class which occupy a position midway, *e.g.*, B. Lactis Aerogenes.

(3) The resistant organisms or those capable of resisting the action of sunlight for considerable time, *e.g.*, B. Cloacæ and B. Grunthal.

Clemesha very rightly insists on the fact that his proposed standards are only tentative ones, and adds that no analyst in any country would ever venture to give a definite opinion without knowing a few elementary facts concerning the source from which the sample has been taken. Such questions, as whether the samples are drawn from lake, river, well or spring—the quantity and date of recent rainfall—the condition in the case of a river, whether in heavy flood or nearly dry—are matters of great importance to the bacteriologist, who has to pronounce an opinion on the subject. Consequently in the application of the method proposed, the question the analyst should always bear in mind is—what chances has this sample had of being exposed to sunlight ?. The more exposure it has had, the more will the arguments

involved in this method apply to the water, and the less it has had, the more guarded must be any expression of opinion. To lakes, tanks, ponds, storage reservoirs, settling tanks, etc., the method is applicable. The extent to which it applies to rivers must depend on the condition of the river itself. The extent to which it is applicable to wells, springs and underground waters generally is uncertain, and this forms a serious limitation to the utility of the method.

PROPOSED STANDARDS.

LAKE WATERS.

Good Lake Water should contain—

(1) less than 100 colonies per c. c. (on agar at 37° C.);

(2) no lactose fermenters in 20 c. c.;

(3) no organisms of class I in 50 c. c.;

(4) the few fæcal organisms isolated should belong to class II and lactis ærogenes should be plentiful.

Fair or usable Lake Water—

(1) should not contain more than 200 organisms per c. c. (agar 37° C.);

(2) lactose fermenters should not be present in less than 5 c. c.;

(3) no organisms of class I should be present in less than 20 c. c.;

(4) lactis ærogenes should largely predominate.

A Lake Water is suspicious—

(1) if it contains more fæcal organisms than 1 in a c. c., even though these be confined to class III; as this indicates that the lake is very low and conditions are suitable for the spread of Cholera.

A Lake Water should be condemned—

(1) if it contains organisms of class I in a c. c. or less;

(2) if fæcal organisms are present in the characteristic proportions seen in fresh fæces;

(3) if lactis ærogenes are absent or scarce. It should be remembered that 48 hours will make an enormous difference in the purity of a lake-water.

Well and Spring Waters.

A good water should contain—

(1) no fæcal bacilli in 20 c. c.;

(2) no organisms of class I in 100 c. c.;

(3) total colonies under 50 per c. c.

River Waters.

Good River Water should contain—

(1) not more than 100 colonies (on agar at 37° C.);

(2) fæcal organisms not exceeding 1 in 10 c. c.;

(3) no organisms of class I in 50 c. c.

Any fæcal organisms present should belong to either class III or to the more resistant class II.

Fair or usable River Water should contain—

(1) not more than 300 colonies (on agar at 37° C.);

(2) not more than 1 in 1 c. c. of fæcal organisms and no organisms of class I in less than 20 c. c.

The fæcal organisms present should consist mainly of mixtures of class III and class II and there should be a tendency for one class of organisms to preponderate.

River Water should be condemned—

(1) if total colonies are more than 800 (on agar 37° C.)

(2) if lactose fermenters are present in number of 10 to 100 per c. c.;

(3) if organisms of class I exceed 1 in 5 c. c., or if the fæcal organisms isolated (class I being absent) are rich in varieties, such as occur in an emulsion of fæces.

As lactose fermenters are frequently present in very small quantities of water obtained from sources which are known to be free from dangerous pollution, the interpretation of results of bacteriological examination of water is rendered very difficult. Taylor has suggested the Ejkman's test, which consists in adding the water in various quantities, to Durham's fermentation tubes containing Peptone, Glucose, and Sodium Chloride, and incubating at 46°C. He finds that the Ejkman test gives more definite value than the test for lactose fermenters at 37°C, and his results show a marked correspondence with the known risks of pollution, pure waters giving a negative result in quantity upto 300 C. C.

The following standards for waters in the tropics have been suggested by Taylor (*vide* INDIAN JOURNAL OF MEDICAL RESEARCH VOL. XVIII No. 4, April, 1931):

(*a*) Surface water and shallow wells. Ejkman test to be *negative* in quantities of water less than 50 C. C.

(*b*) Tube wells. Ejkman test to be negative in quantities of water less than 100.

Discussing the value of the three groups of organisms used as "indicators," Savage (*The Bacteriological Examination of Food and Water, Cambridge Press*, 1914) states—

All three groups of organisms are abundant in crude sewage. The actual number found will of course vary greatly with the strength of the sewage, but the data given by Houston give average figures. These are—

B. Coli and allied forms	100,000	per c. c.
Streptococci	1,000 to 10,000	,,
Spores of B. E. Sporogenes	100 to 1,000	,,

Experiments go to show that members of the B. Coli group are only present when the soil has been contaminated with excrementitious matter, and that virgin soil and soil not manured are free from these organisms; further, that these organisms gradually die out in soil.

In quite pure water, pure air, etc., B. Coli group does not occur.

The organisms of this group do not multiply to any great extent under ordinary natural conditions outside the animal body.

As regards the saprophytic distribution of streptococci, there is no evidence that streptococci have any true home, under natural conditions, apart from the animal body.

Outside the animal body, they may survive for considerable periods but do not thrive. The evidence as to the duration of viability and vitality outside the animal body is somewhat conflicting, but in general, it would appear that the majority are delicate organisms and rapidly die out, though a small number of hardy strains may persist for very long periods.

BAC. ENTERITIDIS SPOROGENES.

In considering the value of this organism as an excretal indicator, it must be remembered that it is a spore-bearing bacillus and that its spores are very resistant. Animal excretal pollution is so widespread that it is not a matter of surprise that such a highly resistant organism should be widely distributed in nature. The available evidence shows that it is absent or relatively absent, from sources which have never been contaminated, but that it is fairly prevalent in sources the pollution of which had taken place possibly at a long antecedent period. These considerations obviously place a considerable limit to its usefulness.

ICE AND INFECTION.

Freezing inhibits the growth of bacteria but does not necessarily kill them. Macfadyen found that liquified air (—318°F) did not kill bacteria, and Typhoid cultures have been proved to be alive even after freezing. Hence the suspicion, that ice may be the cause of spread of infection.

There are a few instances recorded in the literature, of diseases being conveyed by infected ice. The Typhoid Epidemic in Plymouth in 1886, at Rennes in 1895, and in St. Lawrence State Hospital in 1903 have all been traced to ice.

Ice prepared from boiled or distilled water is safe. Occasionally manufactured ice has been found to contain more bacilli than the water from which it was prepared, evidently due to unclean methods of preparation.

Ice may contain more free ammonia than the original water due to the absorption of the gas from the atmosphere of factories where the ice is manufactured.

In India it is common to see the sawdust used to cover the ice being spread on the footpaths to dry up. The chances of the sawdust being contaminated by sputa and excrements on the pavements, and the subsequent infection of the ice is possible. There should be no carelessness in handling ice

on the ground that subsequent cleansing of the ice will remove any surface impurities.

PROTECTION OF WATER SUPPLIES.

When discussing reservoirs, mention has already been made that one must protect the gathering ground of any reservoir, as far as possible. No cultivation of the land should be permitted, nor should any human habitations, other than those necessary for the care-taker or workmen employed, and these must be constructed in such a situation and so drained as to make it impossible for the water supply to be contaminated from this source.

The area should be well wooded and, where possible, fenced off.

No mining or manufacturing operations should be permitted within the area.

In many countries, to control a gathering ground in this manner is a very difficult, if not impossible task, but in India this objection has not quite the same weight.

In regard to wells, the precautions to be adopted have been fully enumerated already.

When the water-supply of a town or village is taken from a river, certain precautions are necessary in addition to those mentioned; especially in India, where so many religious ceremonies are so closely associated with certain rivers at which the village washing and personal ablutions also take place.

The river should be mapped out into three parts. The uppermost portion should be strictly reserved for drinking water and water for domestic purposes, *e.g.*, cooking, washing cooking utensils, etc. The portion immediately below this, in the direction of the flow of the stream, should be reserved, for personal ablutions and the third and lowest portion for washing clothes.

In the presence of an epidemic of Cholera or Typhoid, it may be necessary to take more active measures.

Frequently, the bathing is carried out in pools along the river's edge, and as the bathers use the water to cleanse their mouths—and even drink it—these pools should be disinfected with potassium permanganate, as should also the pools in which the clothes are washed. Efforts should be made to instruct the bathers in the risks they run by swallowing the water. This can best be done by addressing senior men and enlisting their aid. Provision should be made also to supply pure, boiled and ærated water to the bathers by establishing small depots, due observance being paid to religious prejudices, etc.

It is of the utmost importance that water pipes should be laid well away from drains and closets and that the pipes be laid as far as possible in straight lines, and that they be well supported in their course so as to prevent sagging and consequent risk of the opening of joints.

All overflow pipes from cisterns must be made to discharge into the open air and not permitted to be connected to a drain.

No water-closet should be directly supplied by a tap: a cistern must always intervene, as otherwise foul air and filth may possibly be drawn into the pipe.

Bombay Water Works.

The City of Bombay is supplied from three different lakes situated at some distance from the City, *viz.*, Vehar, Tulsi and Tansa.

The Bombay waters are chlorinated at Bhandup, the dosage varying from 0·4 to 0·8 parts per million. The chlorination is effected by making a strong solution of chlorine in a cement concrete tank (strength 1 in 1,500) and regulating it into the main. Two miles down the water is tested for the amount of available chlorine, and rate of entry of the chlorine solution adjusted.

VEHAR LAKE.

Vehar Lake has a gathering ground of 2,500 acres. Its full capacity is 9,120 million gallons. The mean rainfall for several years past is 84·70 inches. The water of this lake is conveyed to the City by means of two cast-iron pipes, one of 24 inches diameter and the other 48 inches reducing to 32 inches diameter. The 24-inch pipe discharges direct into the distributing mains and the latter pipe into the Bhandarwada Reservoir. The main evaporation comes to about $4\frac{1}{2}$ feet per annum. The depth of the lowest outlet below overflow level is 34 feet. The greatest depth of water stored is 61 feet. The height of the lowest draw-off on the T. H. Datum is 232·5.

TULSI LAKE.

The second of these lakes is Tulsi. The area of its gathering ground is 1,385 acres. It has two dams ; the height of the lowest draw-off on the T. H. D. is 399·36 ; capacity available, when the lake is full, 2,294 million gallons ; mean rainfall comes to 103·82 inches ; mean evaporation is $4\frac{1}{2}$ feet per annum ; depth of lowest outlet below overflow level is 57 feet ; greatest depth of water stored is 57 feet. It was constructed in 1879, and is 19 miles from the Town Hall of Bombay. The water is brought into the City by means of cast-iron pipes 24 inches in diameter laid generally above the level of the ground, and discharging into the Malabar Hill Reservoir.

TANSA LAKE.

Tansa is the largest lake. The area of gathering ground is 33,600 acres ; there is only one dam ; height of lowest draws off on the T. H. D. 380 feet ; as originally constructed, the capacity available for supply when the lake was full was 18,600 million gallons ; by the raising of the dam in 1922 the capacity was increased to 35,600 million gallons ; evaporation is about 7 feet per annum ; depth of the lowest outlet below overflow level was 25 feet and has now been increased to 40 feet ; greatest depth of water stored was 110 feet, now

increased to 125 feet; average rainfall comes to 106 inches; it is 58 miles from the Town Hall of Bombay. It was finished in 1891 and the dam subsequently raised in 1915 and 1922. The water was originally brought into the City by means of a masonry conduit as far as practicable. The syphons across the valleys are of cast-iron pipes, 48 inches in diameter laid generally above the surface of the ground; these syphons were duplicated in 1915 by 50-inch diameter steel pipes. In 1927 two lines of 72 inches diameter steel pipes were laid for conveying a daily supply of 90 million gallons from the lake to the City and since then the old masonry conduit has been practically thrown out of use as a means of conveying the water to the City.

CALCUTTA WATER WORKS.

In Calcutta the river Hooghly gives the water supply. The raw water is pumped from the river, into large settling tanks, where the suspended matter settles and the settled water is passed on to the sand filter beds. The filter beds consist of a layer of bricks at the bottom with a spacing of 5″ to 6″. Over this is a layer of gravel 10″ in the old filters and 5″ in the new. On the top of the gravel is Mugra sand 4″ and then river sand 2 feet 3 inches. The depth of water on the sand is 1 foot 6 inches.

After filtration the water collects in the collecting well of the individual filters and then flows through cast-iron pipes into the central collecting wells. It is then pumped into the storage reservoirs, whence it is distributed to the city through the distributing mains. When the filter-bed gets choked after use, about ½ inch of the top river sand is scraped off, and the process continued till only 8 inches remain, after which it is replenished. The filter-bed usually requires replenishment after 15 to 18 months. The indication for scraping a filter-bed is the increased head.

The present supply is 54 million gallons per day, which is proposed to be increased to 83½ million gallons.

POONA WATER WORKS.

The source of water supply at Poona is the Mutha Right Bank Canal. The raw water is pumped into the settling tanks with a capacity of 5·9 million gallons, where the prolonged storage serves to reduce the dose of alum required. The water then passes over the coagulating tanks where alum (usually $\frac{1}{4}$ grain per gallon) is added. The settled water with its fine " floc " of alum passes on to ten rapid filter units each with a capacity of 300,000 million gallons per day. The filtered water is treated with chlorine (0·3 parts per million of water) and conveyed to the covered pure water reservoir with a capacity of $1\frac{1}{4}$ million gallons. The supply then passes by gravitation to the low service zone, or is pumped into the elevated, high and middle service zones.

CHAPTER V.

AIR AND VENTILATION.

The breathing of fresh air is as essential for the maintenance of health and life, as the drinking of pure water and the eating of good food. It is a well-known fact that while starvation kills a human being after some days, deprivation of air proves fatal in a few minutes. Statistics prove that impurity of air is one of the most important causes of ill-health. The average mortality in any country, and more particularly in a country like India, is likely to increase pretty regularly, with density of population. This density favours the spread of organic impurity in the air, consequent on dust, overcrowding, and poverty, and this unfortunately is the normal condition of populous and manufacturing towns in India.

COMPOSITION OF AIR.

Air is a mechanical mixture of certain gases, and its approximate composition is as follows :—

Oxygen	20.95 in 100 volumes.
Nitrogen	78.07 " "
Argon	0.94 " "
Carbonic Acid	0.04 " "
Water Vapour	Varies with the temperature, being more, the higher the temperature.
Ammonia	A trace.
Organic matter	Variable.
Ozone	Variable.
Salts of Sodium ..	Variable.
Other mineral substances	Variable.

The active constituent of air is oxygen which is the supporter of life and combustion. Nitrogen and Argon are merely passive agents, taking no part in the process of respiration, but serving the purpose of innocuous diluting agents. The chief sources of carbonic acid gas in the air are

respiration, combustion, decomposition of animal or vegetable matter, and volcanic and other allied phenomena.

A variety of substances are continually passing into the air in the form of gases, vapours, and solid particles. These would accumulate and render the air unfit for breathing purposes, were it not for certain forces of nature which are continually at work in one form or another, and which serve to counteract their evil effects. Chief of these forces is the property of *diffusibility of gases*, which serves to keep the composition of the air constant, and which causes the CO_2 formed so freely in our large towns to be rapidly removed from where it is formed to other parts, where the processes of vegetation and sunlight can break it up into carbon for the food of plant life, and oxygen for the use of human beings and animals. Gases diffuse at a rate inversely proportional to the square root of their densities.

Supplementary to the power of gaseous diffusion, we have the action of winds, which scatter and diffuse over a large area many impurities of the air which would be very injurious if confined to any limited space. In a similar but lesser degree, dew, rain, and snow may be regarded, as helping in the constant purification and dispersion of atmospheric impurities.

Air is vitiated by (*a*) respiration of men and animals; (*b*) by combustion of coal, gas, oil, etc.; (*c*) by fermentation and putrefaction of animal and vegetable organic matters; and (*d*) by contamination from various trade and manufacturing processes.

VITIATION BY RESPIRATION.

An adult individual at rest respires about 17 times in a minute. At each breathing about 500 c. c. or 30.5 cubic inches of air pass in and out of his lungs. The expired air loses about 4 per cent. of oxygen which is absorbed by the blood in the lung capillaries, and gains CO_2 from the venous blood to the extent of 3.5 to 4 per cent. The nitrogen

remains unchanged. The expired air is warmer, is almost saturated with watery vapour (about 5%) and contains a trace of putrescible organic matter.

An adult male at rest gives off 0.72 cubic foot of CO_2 gas in one hour. This quantity is increased to 0.9 during gentle exercise, and to as much as 2 cubic feet during hard work. Under similar conditions, an adult female is said to give off about one-fifth less of each of these quantities, and an infant yields about 0.5 cubic foot per hour. In a mixed assembly at rest, consisting of male and female adults and children, the CO_2 exhaled per head is estimated to be 0.6 of a cubic foot. It is important to remember this last figure as it is a useful indicator of the respiratory impurities present in the air of a room.

The evil effects caused by the repeated inhalation of air fouled by human beings, under conditions which commonly prevail in overcrowded and ill-ventilated rooms, have now been demonstrated to be mainly due to the *physical changes* which take place in such air. From various experiments carried out in overcrowded living rooms and schoolrooms, it has been found that so long as the temperature and humidity of the air of these rooms are not excessive, the mere increase of CO_2 gas does not produce any injurious effects. But if the temperature and moisture are increased beyond certain limits, the ill effects are immediately made manifest. This is attributed to what is known as "heat retention", by which is meant a partial suspension or inactivity of the normal bodily ability to lose heat by radiation and evaporation from the surface of the skin and from the lungs.

Our sense of well-being then depends upon the rate of heat loss from the surface of the skin or upon the cooling power of the atmosphere. To determine this cooling power of the air, Leonard Hill has constructed an instrument called the Kata-thermometer. It consists of a large-bulbed alcohol thermometer, the alcohol inside being coloured red. The

stem of the thermometer shows two markings ; the upper one corresponds to 100° F and the lower to 95° F. These temperatures are chosen for the graduation of the instrument because the body temperature varies normally between these two limits. Two such thermometers are used, one with the bulb uncovered—the dry Kata-thermometer and the other with the bulb covered with a cap of muslin—the wet Kata-thermometer.

In taking the readings, the bulbs of both the thermometers are immersed in water at about 150° F. The alcohol being heated, expands and rises into the stem of the instrument. The heating is continued till the alcohol has partially filled up the small bulb at the top. The excess of water is mopped off from the wet thermometer and the other is dried up with a piece of cloth. The alcohol cools down and begins to fall in the stem. The dry Kata loses heat by radiation and convection and the wet, mainly by evaporation of moisture, but to a certain extent by radiation and convection. The time required for alcohol to fall from 100° F. to 95° F. is noted in seconds by means of a stop-watch. At least four such readings are taken with each thermometer. The first reading is discarded because the glass of the thermometer takes some time to be equally heated and to come into equilibrium with the alcohol. An average of the other three readings is taken. On the back of the stem of each thermometer is marked a figure with the letter F. (factor). This figure is the number of millicallores of heat which each centimeter of the bulb surface loses during the time the alcohol falls from 100° F. to 95° F. The factor for each thermometer is different. This factor when divided by the average number of seconds found by the experiment gives the result, as loss of heat in milli-callories per square centimeter of the surface per second. Since the thermometers lose heat in the same way as the human body does, the results applied to the body indicate heat loss from the surface of the skin. To secure comfort in an atmosphere, it is said that the dry

Kata should give a result of 6 and above, and the wet, of 20 and above. In India, on account of higher atmospheric temperatures, it is not possible to obtain such results and a large number of observations carried out in Bombay have revealed that the dry Kata does not give results of more than 3 and the wet of more than 12. In exceptional cases, during winter with a strong breeze blowing, the results have come upto 5 and 18 only.

In certain places, where the atmospheric temperature is ordinarily higher than the highest graduation of the thermometers, the alcohol would remain always heated and filling up the stem and the bulb at the top of the instrument. To take the readings in such cases, it is recommended that the alcohol should be cooled down, by immersing the bulb in ice-cold water and the readings taken by noting the time required for the alchol to rise from the lower to the upper mark.

The purity of the air in dwelling houses depends on the air space allotted to each individual, and the facilities rendered for adequate ventilation. Where these conditions are wanting, injury to health results. The immediate effect of breathing air vitiated by respiration in a room where many persons are temporarily huddled together, is headache, a sense of depression, drowsiness, nausea, and fainting. The long-continued breathing of stuffy air tends to produce a lowered condition of vitality, characterized by anæmia, lassitude, anorexia, dyspepsia, and depression of spirits, and is probably one of the causes of rickets in children.

The researches of Dr. Ogle have shown, that those persons whose occupations are carried on in the open air such as farmers, gardeners, agricultural labourers, and fishermen, are generally the most healthy and have the lowest death rate. They are particularly free from phthisis and other diseases of the respiratory organs. There is no doubt that the spread of phthisis is due to foul air caused by overcrowd-

and insufficient ventilation, because the excessive incidence of this and other pulmonary diseases among the inmates of slum areas and back-to-back houses, has been clearly established. Another convincing proof of this is to be found in the comparative immunity enjoyed by soldiers, sailors, and prisoners in England, at the present time from phthisis, owing to their being housed in well-ventilated barracks and jails, with an adequate amount of cubic space.

Owing to the ease with which contagion can pass from the sick to the healthy in over-crowded and ill-ventilated rooms, various infectious diseases, such as small-pox, relapsing fever, typhus fever, measles, and influenza are more prevalent where such conditions exist.

It has also been found that under such conditions existing in school dormitories and class-rooms, there is a predisposition to inflammatory conditions of the throat, such as follicular and ulcerative tonsillitis, which in some cases may develop into diphtheria, owing to a favourable nidus being afforded to the introduction of the bacillus of that disease. Similarly in ill-ventilated hospital wards, inflammation of the throat and tonsils, known as "hospital sore-throat", is likely to occur.

Lastly certain parasitic skin diseases are also liable to spread in rooms where there is absence of ventilation and air-space.

VITIATION BY COMBUSTION.

The combustion of coal, wood, oil, coal gas, and candles gives rise to certain impurities in the atmosphere, such as carbon dioxide and monoxide, sulphur dioxide, some ammonium compounds, and moisture. From the point of view of public health, the most important are carbon dioxide which is a comparatively harmless compound, and carbon monoxide, which is an active narcotic poison. It is very necessary that we should appreciate the difference between these two gases. It is this latter

gas which is the source of danger when a fire in a *segree* is burned in a closed room. Cases of death due to charcoal fumes are not infrequent, and therefore it is important to realize this danger. Stoves and particularly charcoal *segrees* should never be lighted in closed rooms. This CO gas, as it is odourless and does not cause any irritation of the air-passages when inhaled, is very insidious in its effects. The exhaust fumes of petrol engines of motor cars contain this deadly gas, and therefore they are likely to be dangerous in confined spaces, such as garages, if the motor engines are not stopped at once.

Professor Corfield was of opinion that slight escapes of coal gas into houses, owing to defective pipes and burners, gave rise to cases of relaxed and ulcerated sore throat. It is necessary, therefore, in order to obviate the evil effects of impurities in the air arising from combustion, to provide for the supply of a sufficient quantity of air. 240 cubic feet of air should be allowed for the complete combustion of one pound of coal, and 120 cubic feet for one pound of dry wood. For every cubic foot of coal gas consumed, about 1200 cubic feet of fresh air is necessary.

Smoke Nuisance and Its Prevention.

The emission of black smoke from the chimneys of factories in the various manufacturing towns in India is a source of nuisance to the residents in the immediate vicinity of the factories. The smoke nuisance in factories is generally due to two causes: (*a*) careless stoking, and (*b*) absence of appliances for the supply of an adequate quantity of air for the complete combustion of coal. Firemen are in the habit of allowing too long intervals between the firings, and this leads to a large quantity of coal being put on at one firing, with the result that black smoke is produced. The best method of smoke prevention is to secure frequent and light firing by the provision of mechanical stokers, and the admittance to the furnace of the requisite quantity of air, by means

of forced-draught appliances, to provide for the complete combustion of the carbon particles after each fresh charge of fuel. The quality of coal used is also a factor in the production of smoky chimneys. The use of electrical instead of steam engines in the various Bombay mills has abated the smoke nuisance in the City in a large measure. In Bombay, there is a special Smoke Prevention Committee appointed by Government to deal with smoke nuisance prevention. They have adequate powers of dealing with offenders, and one of their functions is to advise the owners of factories how to work them without causing smoke nuisance.

The London County Council is of opinion that the escape of black smoke for five minutes from the lighting of the furnace might be permitted, but that afterwards a discharge of one minute or more will raise the question of a statutory nuisance under the Public Health Act, 1891. The allowance varies from two to fifteen minutes in other large towns.

VITIATION BY FERMENTATION AND PUTREFACTION OF ORGANIC MATTERS.

The air of sewers, drains, and cesspools has long been regarded as dangerous. The gaseous products of the decomposition of animal and vegetable organic matters are evil-smelling and highly complex bodies of the nature of the compound ammonias, as well as simpler gases such as carbonic acid and sulphuretted hydrogen. The latter gas is most dangerous, and has frequently been the cause of sudden death amongst workmen employed in cleaning old sewers and drains. When this gas—H_2S—is present even in the proportion of 1 in 7000, it is dangerous to human life. Wherever therefore it is necessary to enter an old or foul sewer the following precautions should be taken :—Open the lids of the two adjacent manholes, and leave them open for two to three hours, so as to secure free ventilation and dilution of the gas. Then cautiously lower a lighted candle into the sewer, into which the workmen should on no account enter, unless the

candle burns brightly. If there is a likelihood of explosive gases being present in the sewer, a miner's safety lamp should be lowered, or a rat in a cage. In the latter case, should the animal remain lively for ten minutes in the sewer it may be considered safe for the workmen to go down. It is also advisable and necessary to tie a strong rope round the shoulders and ankles of the workmen, so that should they be overpowered by gas, they can be drawn back and extricated by comrades who should always be in readiness. The wearing of proper masks is also a safe precaution against poisoning by this and other deleterious gases in sewers. The best remedy for men overpowered by sewer gas is artificial respiration, or oxygen inhalation if available. Liquor Strychnia should be injected subcutaneously, and hot water bottles applied to the extremities.

The air of sewers, so long as they are properly constructed with good gradients, and are free from silt, is remarkably free from microbes and deleterious or dangerous gases. It is now believed that the air of sewers plays very little part in the conveyance of typhoid fever. The long-continued inhalation of minute doses of sewer air in badly drained houses produces a general loss of health, more particularly in children than in adults. A severe form of tonsillitis, known as "sewer air throat" is common among the inmates of such houses. The special diseases, that have been more particularly noticed in connection with sewer air, are diarrhœa and diphtheria.

VITIATION IN INDUSTRIAL OCCUPATIONS.

There are a great many industrial occupations which are injurious in proportion to the amount and nature of the dust produced, to the workmen engaged in them. The conditions under which the dust-producing work is carried on, whether in the open air, in properly ventilated work-shops, work-places, or factories, or in ill-ventilated and over-crowded rooms, are important factors in the consideration of this

mode of vitiation of the atmosphere. As a general rule it may be mentioned, that the long-continued inhalation of dust produces diseases of the lungs, such as bronchitis, fibroid pneumonia, asthma and emphysema. The soft or rounded particles of dust are not capable of doing nearly so much mischief, as those particles which are hard, sharp and angular.

EVIL EFFECTS OF INHALING THE VARIOUS KINDS OF TRADE DUST.

Mineral dust is much more irritating than dust of animal or vegetable origin. Cornish miners suffer from fibroid phthisis and other respiratory diseases owing to some condition peculiar to tin mining, where the dust disengaged is more irritant than in other mines. Workers in lead mines suffer from lead poisoning and bronchitis. In copper mines, the metallic dust produced therein is said to cause gastric and intestinal irritation. Steel grinders, millstone cutters, stone masons, sandpaper makers, and weavers are all liable to suffer from pulmonary diseases caused by the inhalation of dust. In regard to dust of vegetable origin, workers in cotton-sorting and cotton cleaning factories are very much exposed to annoying dust. The introduction of closed machinery in this trade has done much to mitigate the evils arising in the process of manufacture. Similarly in the spinning and sizing of cotton, and in flax factories a good deal of irritant dust is produced. Dust from wool has produced anthrax. Match-makers formerly suffered from necrosis of the lower jaw. The substitution of red or amorphous phosphorus has obviated this danger. Brass-founders inhale fumes of oxide of zinc and suffer from fever, nervous depression, cramps and diarrhœa. Arsenic in the form of Scheele's Green is the cause of great suffering to workmen employed in the making of artificial flowers, or wall papers. Plumbers, painters and manufacturers of white lead may get colic and palsy.

Certain trades, such as Alkali Works, Chemical Works, and Brick fields, give off various deleterious gases, and thus render the atmosphere impure. The gases which usually escape from such works are Hydrochloric acid gas which destroys vegetation round about the works, ammonia, ammonium sulphide and sulphuretted hydrogen. The air from brick-fields is usually very pungent, and contains much carbonic oxide. The air of printing offices contains antimony from the type metal, which consists of lead, tin and antimony.

The bad effects of trade impurities can to a certain extent be prevented by adequate ventilation, as in mines. In steel grinding, the use of the "wet" grinding, proper ventilation of the wheelboxes, and the use of respirators, are useful safeguards. In very dusty factories, the provision of shafts, and ventilation by extraction, are very desirable. In match-making, the use of the amorphous form of phosphorus, and the inhalation of the vapour of turpentine by the workers is recommended. Painters, plumbers, etc., should clean their hands and mouth carefully before eating, and use sulphuric acid lemonades as drink.

VENTILATION.

The term ventilation has a fairly wide meaning. Ordinarily it is meant to imply the various measures taken for the removal and dilution of the different impurities which would otherwise accumulate in the air of buildings inhabited by men and animals, as the result of the vitiating processes already described. This is known as *internal ventilation*, as opposed to the term *external ventilation*, which means the ventilation of streets and buildings, and is dependent on the width of streets, the height of adjoining or opposite buildings, in fact with the amount of free air space around the buildings, and the ease with which light and air can enter into them. This *external ventilation* is a subject of very great importance, as on the purity or otherwise of the outside air, a great deal depends on the possibility of efficient *internal ventilation*.

In order to effect the ventilation of living rooms, the following points must be considered :—(*a*) the amount of fresh air required ; (*b*) the cubic and floor space ; (*c*) the direction of the ventilating currents ; and (*d*) the rate of movement of the currents, as there ought to be no perceptible draught.

In regard to the supply of fresh air to dwelling rooms, it must be remembered that CO_2 is regarded as the chief index of air vitiation. The question therefore naturally arises as to what should be the standard of purity of air in such rooms or houses. Professor De Chaumont found after the examination of a large number of samples of air of inhabited rooms, that when the amount of respiratory CO_2 in a room exceeds 0.6 volumes per 1000, a close or disagreeable odour is perceived, owing to the coincident increase of foul organic matter in the air of the room. The amount present in the outside air being 0.4 per 1000, it was held by De Chaumont that vitiation to the extent of 0.2 per 1000 may be allowed with impunity, but not over and above that standard. Hence the "permissible limit" of respiratory impurity is .2 per 1000, which is the same thing as .0002 cubic foot of CO_2 in one cubic foot of air. Now since each individual on an average, when at rest, gives off .6 of a cubic foot of CO_2 in one hour, it follows that the air he breathes out must be diluted with 3000 cubic feet of pure air, so that the CO_2 in it may be reduced to the above limit of respiratory impurity. This is the standard now accepted and can be expressed by the equation $D = \frac{E}{r}$ where E=the amount of CO_2 exhaled per head per hour in cubic feet, r=the permissible limit of CO_2, due to respiratory impurity, stated per cubic foot, and D=the delivery of fresh air required in cubic feet per head per hour. Hence $\frac{\cdot 6}{.0002} = 3000$, the number of cubic feet of air necessary for every individual per hour.

The amount of cubic space allotted to each person in a room is a matter of great importance in ventilation in cold

climates. It is necessary in such climates that the air of a room should not be changed oftener than three times in an hour, otherwise a very disagreeable draught is likely to be created. Hence in England and other cold countries, a cubic space of 1,000 cubic feet per head is recommended, so that the air of a room need be changed only three times per hour, in order to supply the required quantity of 3,000 cubic feet of air per head per hour.

But along with cubic space, what is more important is that a certain amount of superficial or floor space is necessary for each individual, because if the height of a room exceeds 12 feet, excess in this direction does not compensate for deficiency in the other dimensions, although the total cubic space may be the same. The reason of this is, that the organic impurities of respiration are not equally diffused throughout the air of a room, but tend to hang about in the lower strata, consequently excessive height does not mean a corresponding dilution. It will therefore be understood that the height of a room over 12 or 13 feet is perfectly redundant and useless from the point of view of ventilation. Then again, a larger amount of floor space will lessen the risk of the spread of infectious diseases in over-crowded rooms where persons are closely huddled together.

Professor De Chaumont's above mentioned standard of 3,000 cubic feet of fresh air, which is based on the permissible limit of respiratory impurity not exceeding ·2 per 1,000, has been followed for many years. But recent experiments made by Kenwood have shown that in many work-rooms and in senior class rooms of elementary schools, stuffiness of the atmosphere is not perceptible until the respiratory CO_2 exceeds ·3 per 1,000. If this latter figure were accepted, the result would be that De Chaumont's standard of 3,000 cubic feet would be reduced to 2,000 cubic feet, an amount which is not only far more practicable in sufficing to prevent stuffiness, but in which the physical condition of the atmosphere, *i.e.*, temperature and humidity, would continue to be satisfactory.

In the ventilation of factories, the principle to be borne in mind, is the same as in the case of ordinary buildings or dwelling rooms. It must however be remembered, that during exertion, an individual gives off more respiratory impurities,—as much as 2 cubic feet of CO_2 in one hour—than when at rest. For this reason, and also because the air is further vitiated by the trade processes, the amount of air supplied to factories should be considerably in excess—double or even treble—of that required in ordinary living or sleeping rooms. The amount of cubic space required in non-textile workrooms in England is 250 cubic feet per head. In the same workrooms during overtime, 400 cubic feet of space is required.

In the case of hospitals, the hourly supply of fresh air should be 4,000 cubic feet per head, and the cubic space should be from 1,200 to 1,500 cubic feet. In regard to infectious diseases hospitals, the cubic space recommended is 2,000 cubic feet. It is essential to have plenty of floor space around each bed in hospitals, to facilitate the attendance and nursing of patients. In general hospitals, at least 100 square feet per bed is necessary. In surgical and lying-in wards, a wider separation of beds is desirable. In such cases 130 square feet of floor space is necessary, and in the case of infectious diseases hospitals, a floor space of 144 square feet should be provided.

There are two different forms of ventilation, *viz.*, Natural and Artificial. Natural ventilation depends on certain forces which are continually acting in nature, such as diffusion of gases, action of winds, and differences in weight and volume of masses of air of unequal temperature.

The effect of diffusion, as a ventilating agent, is not very marked. Winds are the most important ventilating forces in this country. They act in two ways:—(*a*) by direct action, blowing through and through, *i. e.*, "perflation"; (*b*) by their aspirating action, as blowing over a chimney; the air

in motion causes a partial vacuum or rarefaction in its path, and then the air is naturally forced from the place of greater pressure to that where it is less, and the wind therefore sets up a current at right angles to itself up the chimney.

The "perflating" action of the wind is best utilized by having windows facing the current of the wind, and this action is increased when windows, or a window and door on opposite sides of a room are left open. By means of this force, dwelling and other rooms can be rapidly and continuously flushed with air, so much so that it is possible to renew the air of such rooms over a hundred times an hour. The most simple and direct methods of ventilation are the best for this country. All tubes, shafts, valves, and fire-places are, as a rule, unnecessary, except in hill stations and certain places in northern India, where the climate is nearly akin to that of Europe. In single-storied buildings with low roofs, ridge ventilation, with grated openings over each door and window, is all that is necessary, or instead of grated openings, fan-shaped moveable glass frames or ventilators may be provided in better class buildings.

The great drawback against the wind as a ventilating agent is, that its movements are very uncertain, and they are difficult to regulate. When the wind falls entirely and there is a dead calm, we have to create movement by artificial means, such as fans and *punkhas* either driven by hand, or better still by electric power. The climate of Bombay is made fairly tolerable in the hot months of the year, by means of electric fans.

In many parts of India where extremes of temperature prevail in the cold and hot months of the year, it becomes necessary to cool the air of rooms in the latter months. For this purpose, what are known as "Thermantidotes" are used. These are fan wheels usually driven by hand, used for propelling air into a room or house, the air being cooled by passage through a wet mat made of *kus-kus* or other grass.

The temperature of houses, particularly in dry climates, can thus be readily lowered by 20° F. or more. The effect of cooling and moistening air in this manner, is sometimes prejudicial to health on account of the sudden change, and perhaps sometimes owing to the use of bad water. For this purpose, it is wise to add a little permanganate of potash to the water. Wet mats besides cooling the air, and increasing its moisture, act as filters and remove a large proportion of suspended impurities which it may contain.

The third force in nature on which ventilation depends, *viz.*, the differences in weight and volume of masses of air of unequal temperature, is chiefly relied on for ventilating the interior of buildings in cold climates. It is brought more into play in cold weather, when the difference in temperature of the air inside and outside the house is considerable. The principle underlying this force is, that when air is heated it expands. A volume of hot air is therefore lighter, bulk for bulk, than the same volume of cold air. The warm air rises, and equilibrium is restored by the cold air passing in to occupy its place.

Practical ventilation in cold climates is more or less an engineering problem. One important point in such climates is, that when fresh air which is not previously warmed is admitted into the rooms, it should be given an upward direction and it should be made to enter above the heads of the occupants, so as to avoid draughts. For this purpose, various contrivances for windows are made. One of the best known and simple arrangement is that of Hinckes-Bird. The plan is to raise the lower sash, insert a piece of board so as to completely close up the opening thus made. In this way the fresh air comes in at the middle between the sashes, and is directed upwards towards the ceiling. The provision of a glass louvre in the top centre pane, the use of double panes, the outer one open at its lower border, and the inner one open at its upper border, the use of panes of perforated glass, all effect the same purpose.

In all methods of ventilation based on this force, suitable and adequate inlets for fresh air and outlets for the escape of impure air, must be provided. The window arrangements described above serve as inlets. Besides these, several wall inlets are employed, such as Sheringham's valve, Tobin's tubes, and Ellison's perforated bricks.

Sheringham's valve consists of a perforated iron or zinc plate, through which the air enters, and a valved plate with side-checks, which directs the air-current straight up towards the ceiling. The valved plate is hinged at its lower border and can be closed, when required, by means of a balanced weight. The size of the inlet opening is 9 inches by 3.

Tobin's tubes consist of vertical tubes carried up the walls of the room to a distance of six feet or so, so as to obviate draughts. In both these contrivances it is possible to filter the entering air through muslin or cotton-wool.

Ellison's bricks have conical holes, the smaller openings being outside, and the larger, inside.

The total size of inlets and outlets should be about 24 square inches per head. The best situation for outlets is the top of the room, because the escaping foul air is warmer and consequently lighter than the incoming fresh air. The openings of the inlets should be as large or even larger than those of the outlets, otherwise counter currents may set in and interfere with the exit and cause draughts.

Artificial ventilation is brought about either by the "vacuum method", *i.e.*, extraction of air, or by the "plenum method" or propulsion of air. The commonest example of ventilation by extraction is the action of an ordinary fire-place, which, by heating a column of air, causes its expansion, ascent, and replacement by another colder volume of air. Fire-places should be grouped in the centre of the house, because if they are on an external wall, much of the heat is likely to be lost by radiation. In the "plenum system" air is driven mechanically either by bellows, pumps, or fans

into proper channels. This method of artificial ventilation is more suited to factories and workshops.

EXTERNAL VENTILATION.

As already mentioned this subject is of very great importance from the public health point of view. It is most essential in the planning of a town that the arrangement of its streets and the construction of its houses, should be on a definite plan. Every old town in India, including many of its important cities, presents examples, of narrow streets, winding lanes, close aggregation of buildings, forming an insanitary labyrinth, which cannot be efficiently cleansed, and in which the air is almost always stagnant. Persons living in such congested areas have a low vitality and are predisposed to various diseases. The air of such areas is specially injurious to infants and children, and furnishes one of the causes of high infantile mortality. It is necessary that in existing towns, and also when it is intended to develop a new town, provision should be made to lay out the streets on a definite plan, and when so laid out, the houses erected in it, should be subject to regulations as regards their height, depth, site, the area they occupy, their relation to one another, and the amount of open space to secure a free circulation of air for each of them.

One of the chief defects in the sanitation of Bombay is overcrowding, including not only insufficient and insanitary housing accommodation, but also overcrowding in space or the close aggregation of buildings without adequate open spaces between and around them. Prior to the year 1905 there was no provision in the Municipal Building By-laws, for open spaces between and around houses. The common house gully, which is from 2 to 5 feet in width, serves the purpose of an exterior open space, throughout the crowded portions of the City. The purposes to which a house gully is put are well known. It is the repository of all the house

refuse, and all the down-take pipes discharge into it. Any air admitted from such a filthy exterior open space, can never be pure, and must exercise a prejudicial effect on the health of persons occupying such buildings.

In the year 1905, a by-law was enacted which stated that every room intended for human habitation should have the whole of at least one side, abutting on an interior or exterior open space, the minimum size of which varied with the height of the building. The maximum width of the exterior open space insisted upon was 12 feet, if the building was 66 feet high. The minimum interior open space was defined as a space not less than 6 feet across, the area of which was not less than $\frac{1}{10}$th of the aggregate floor area of all the rooms abutting on it.

The Bombay Improvement Trust, which was established in the year 1898, has brought about considerable improvement in the City by constructing wide arterial roads, and demolishing slum areas. The Trust rules do not define the minimum open space as regards its width or other dimensions, but both in regard to external or internal open spaces, require that every room depending for light and air on such space, shall receive not less than $63\frac{1}{2}°$ of light. Roughly, this $63\frac{1}{2}°$ standard means that throughout the length of one side of every living room, there shall be external air-space open to the sky extending to a distance, measured horizontally from the room wall, of at least half the height of the top of the opposite house above the floor of the room. It is called the $63\frac{1}{2}°$ rule, because the angle at which light from the minimum air-space so prescribed will strike the floor, is an angle of approximately $63\frac{1}{2}°$ which has a tangent of $\frac{2}{1}$. Thus if an open space between two houses is only 10 feet wide, the height of each house above the plinth must be limited to 20 feet, if the lowest rooms are to satisfy the $63\frac{1}{2}°$ rule; and if two houses of the maximum height ordinarily allowed in Bombay, *viz.* 70 feet, are built side by side, then to satisfy the $63\frac{1}{2}°$ rule, that space must be 35 feet broad. According to the old

Municipal rules, these buildings of maximum height need only be 12 feet apart. In the latter case, the ground floor rooms would be dark, whereas in the former case the occupants of the ground floor rooms would be able to see the sky without going out of their rooms, a thing impossible in many houses built in accord with Municipal rules.

In regard to interior open spaces, suppose we have a building 36 feet high, and that in this building there are on each floor 12 rooms, each a 100 square feet in area, and that the 12 rooms abut on either side of a central chowk, and that the side of each of the rooms next the chowk is 10 feet wide. Under Municipal rules the chowk or interior open space need be only 60 feet × 6 feet. In the case of the Trust rules the space must be 60 feet × 18 feet.

In the year 1919, the Bombay Municipal Corporation revised the Building By-laws in respect of open spaces to be maintained for light and ventilation of buildings. Two different standards have been fixed, one for each of the two parts into which the City is divided for the purpose of these by-laws. The less thickly populated area, where the buildings are comparatively scattered, is subject to the standard of $63\frac{1}{2}^\circ$ light and air, and a lower standard is fixed for the remaining part of the City, which is known as the "scheduled" or "congested" area. These by-laws are no doubt a great improvement on those in force prior to 1919 but there is one drawback in them, in that their application depends on the co-operation and good will of the owners of neighbouring properties. The defects and intricacies of By-law 41-A, which enforces the standard of $63\frac{1}{2}^\circ$ light and air are explained below :—

For the application of Building By-laws Nos. 41 and 41-A the City of Bombay has been divided into two distinct Zones :—

(1) Those parts of the City which are comprised in what are termed as congested or scheduled areas, and

(2) The remaining parts of the City situated outside the scheduled areas mentioned in (1).

We have here to deal with By-law 41-A only.

It applies to all the buildings in the non-scheduled areas, as also to buildings that may be constructed on the sites previously *unbuilt* upon in the scheduled areas. (It may here be stated in passing that By-law 41 applies only to the buildings on the sites *previously built upon in the scheduled areas.*)

By-law 41-A requires that every building, whatever its use, should be provided on its front and rear sides with "adequate means of access for external *air*," in other words, every building should be provided with certain amount of open *air* space, on the front side as well as on the rear side. If there are any dwelling rooms in such a building, they should in addition be provided with "adequate means of access for external *light* also," in other words, these rooms should abut on open spaces of certain dimensions for receiving light.

FRONT AIR SPACE.

Every building should have a front open air space equal in width to half the height of the building. For instance, if a building is 70 feet high the front open air space should be 35 feet wide and so on. Generally as the majority of the buildings abut on streets and roads and as their heights are regulated by the respective widths of the streets and roads (*vide* Section 349-B of the City of Bombay Municipal Act), the requisition of By-law 41-A as regards the front open air space is automatically complied with in many cases.

The following instances will make the point clear :—

Width of street.	Front height allowable under Sec. 349-B.
20 Feet	30
26 ,, ...	39
30 ,, ...	40
40 ,, ...	40
50 ,, ...	50
60 ,, ...	60
70 ,, ...	70

But in cases where the buildings are situated away from a street or abut on streets less than 30 feet in width, certain special requisitions are to be complied with. The by-law requires that no building should be constructed within a distance of 15 feet from the centre line of the street. Suppose a street is 30 feet in width, then the building will be at a distance of 15 feet from the centre line of the street and there will be no objection to this building being erected touching directly the edge of the street. But in case where a street is 25 feet in width, then the house owner will have to leave within his own premises and between the edge of the street and the front line of his proposed building an open air space of $2\frac{1}{2}$ feet in width so as to keep the front wall of the building at a distance of $(12\frac{1}{2}+2\frac{1}{2})$ 15 feet from the centre line of the 25 feet wide street. Similarly if a street is 20 feet in width the intending builder should leave an open air space of 5 feet before he starts his building.

In the case of a building which does not directly abut on a street, but it is situated away from a street, say, in the compound of any premises,

the by-law requires that it should have a front open air space equal in width to half the height of the building, but with this proviso that such front air space shall not in any case be less than 15 feet in width. Suppose for instance, the height of such a building is 40 feet, then the width of the front open air space within his own premises should be 20 feet. Suppose a building is 30 feet high, then such front air space should be 15 feet in width. Suppose a building is 20 feet high, still the front air space should be fifteen feet in width, it should never be less than 15 feet.

REAR AIR SPACE.

Every building should have a rear open air space equal in width to half the height of the building. For instance, if the rear height of the building is 70 feet, the width of the open air space in the rear of it should be one half of 70 feet, 35 feet and so on. This rule is subject to the proviso that the rear open air space should be not less than 10 feet under any circumstances. Suppose a building is 10 or 15 feet high, still the rear open air space should be at least 10 feet in width.

OPEN SPACES FOR LIGHTING OF ROOMS USED FOR DWELLING PURPOSES.

The width of an open space for *light* depends not only on the height of the building proposed to be constructed, but also on the height of the existing neighbouring building on that side on which the rooms of the proposed building are to abut. Suppose for instance a building to be used as a dwelling is proposed to be constructed 40 feet in height and is to have rooms also along its north side. Further assume that there is already existing a neighbouring building on the north side, which is 70 feet in height. The width of the space required to be provided for lighting the north side rooms of the proposed building, 40 feet in height should not be 20 feet but should be half of 70 feet, *viz.*, 35 feet. Take a contrary case. Suppose a proposed building is to be 70 feet in height and the existing neighbouring building is only 20 feet in height, still the open space for light should be 35 feet in width. In fact the width of the space for light should not be less than half the height of the proposed building or half the height of the existing neighbouring building, whichever is the higher of the two. This requisition is rather disadvantageous to a prospective builder, if the neighbouring building by his side happens to be a very high one. The only way to get over this difficulty is to design the new building in such a manner that the dwelling rooms therein do not abut on that side on which a very high neighbouring building is already standing. This requires skill and ingenuity on the part of the architect. The same object can likewise be gained by constructing the new building by having open terraces of proper widths at different floor-levels so as to secure the angle of light as required by the by-laws. The minimum open space for *light* should not be less than 10 feet in width under any circumstances, whether a building is 10 feet high or 20 feet high.

Lastly it must be stated that the minimum front and rear open space of 15 feet and 10 feet respectively for ventilation purposes and the minimum open space of 10 feet for purposes of light should be provided wholly within the owner's own premises.

For any extra open space required beyond the minimum (as required by the height of a building), an owner can be allowed the benefit of the adjoining open air spaces in the neighbouring premises, provided the latter spaces are assured by legislative enactment, or by Municipal By-laws or by contract to be permanently kept open and unbuilt upon, but this is subject to the condition that in no case the total width of the open spaces so provided out of the premises of two different persons is less than the exact width required by the foregoing regulations.

The insanitary features of dwelling houses in the crowded areas of most of the large cities in India are more or less similar. To begin with, the houses are built almost back to back. The depth of the houses from front to back is excessive ; there is a central passage inside the house with rooms abutting on either side of it. There may or may not be a gully at the sides of the houses, and if one exists it is generally not more than two feet in width. As a result of this, the building as a whole, except the front rooms are deficient in light and ventilation, the centre rooms being often in absolute darkness. The gullies, as has been mentioned above, serve the purpose of exterior open spaces. They are open channels for carrying off sullage, but in many cases they are so imperfectly paved, as not to be water-tight, and sometimes their gradient towards the street drain is faulty. Some of them serve as passages for sweepers, and are flanked on either side by a row of basket-privy shafts. The trap doors of the shafts abut immediately on the gully, and when the receptacles get full and overflow, the liquid night-soil is discharged on the surface of the gully. In some cities such as Poona, Nasik, Surat, Ahmedabad, the trap doors of privies are seen at the entrance of houses. Refuse of all kinds is also thrown into the gullies from the windows abutting on them. For these reasons the gullies, though repeatedly cleansed, are generally in a foul dirty and evil-smelling condition, and windows which overlook them have to be kept closed to exclude the smell. Hence such gullies are of little use for purposes of ventilation. The labouring class of people, owing to their ignorance, object to light and air, and it is common to see in Bombay, even the model Improvement Trust chawls with rags, bags, and old sarees, stretched across the windows.

MODE OF DEALING WITH EXISTING INSANITARY AREAS.

Slum or unhealthy areas can sometime be rendered habitable, by clearing out a portion of the interior of the blocks, and providing open spaces behind the houses, with back-lanes for drainage and scavenging purposes. It is also a good plan to reduce the depth of houses, by demolishing the central rooms, and providing instead, an interior open space whose width should be in one dimension, half the height of the building. But if these alterations are for some reason or other insufficient or impracticable, then complete demolition of the area, and re-building it on sanitary lines, are the only remedies applicable.

EXAMINATION OF AIR AND VENTILATION.

For the ordinary examination of the air and ventilation of dwelling rooms, the following procedure should be adopted :—(1) Inspect the

premises from outside, to seek any possible causes of contamination of air entering a building, such as accumulation of decaying refuse, foul drains or latrines, and choked waste-water pipes, in the vicinity of the doors or windows. (2) Then inspect the interior of the building to seek causes of contamination from within, such as dirt on the floors and walls, accumulation of refuse or filthy clothes, foul drains, and *nahanees.* (3) Then you will proceed to examine whether the ventilation of a room under ordinary conditions is sufficient or not, and for this purpose, a room should be examined early in the morning after it has been occupied by the full number of inmates during the night, and in its usual condition of ventilation, before such doors and windows as are closed at night, have been thrown open. There are two rough and ready tests for this examination :—(*a*) *Smell-test.* To carry out this test, remain for sometime in pure open air, and then rapidly enter the house or room and notice the odour if any. If the air in the room does not differ sensibly from the outside air, the ventilation may be regarded as perfect. If otherwise, you will note the degree of stuffiness of the atmosphere, such as close, unpleasant, or very close and foul. (*b*) *Lime water-test* :—This test is for determining as to whether the amount of CO^2 in the room is above or below the " permissible limit". To carry it out, take a clean, dry, wide-mouthed bottle of the capacity of about $10\frac{1}{2}$ ounces, fill it up with clean water, and empty it in that part of the room, the air of which is intended to be examined, and allow it to drain well. By so doing, air will take the place of the water in the bottle. Half an ounce of lime water, carefully measured, is then poured into the bottle, which is to be well stoppered or covered with an India-rubber cap, and set aside after being well-shaken. After the lapse of six hours the lime water in the bottle should still be quite clear when shaken up. If it is turbid, it denotes that more than .06 per cent. of CO^2 is present in the air examined.

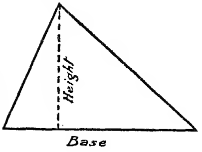
The next procedure is to measure the amount of cubic space and floor space in the room. If the room be square or oblong with a flat ceiling, the cubic space will simply be the three dimensions of length, breadth and height multiplied into each other. If the room be circular or of a regular form, with a curved ceiling, the following rules for the measurement of circles, triangles, etc., should be used :—

CALCULATION OF AREAS.

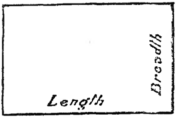
Triangle.

Area=Half the product of base and height.

This may be obtained by multiplying the base by the height and halving the product, or by multiplying the base by half the height or the height by half the base.



Quadrilateral or Four-sided Figures.

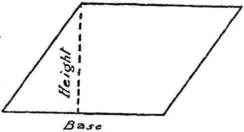


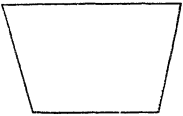
Rectangle and square (in both of which all angles are square).

Area=The length multiplied by the breadth.

Rhombus or rhomboid (in which the opposite sides are parallel).

Area=The base multiplied by the perpendicular height.



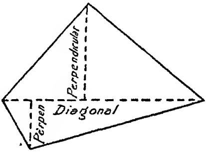


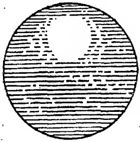
Trapezoid (in which two sides only are parallel).

Area=The mean length of the parallel sides multiplied by the perpendicular distance between them.

Trapezium (which has none of its sides parallel).

Area=Half the sum of the perpendiculars multiplied by the diagonal on which they fall.



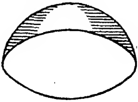


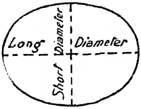
Globe or Sphere.

Volume = Cube of diameter multiplied by one-sixth of 3·1416 (*i.e.*, ·5236), *or* area of circle having same diameter as sphere multiplied by two-thirds the diameter.

Segment of a Sphere:

Volume=Area of base multiplied by two-thirds of the height.





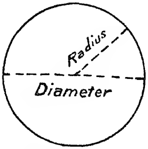
Ellipse.

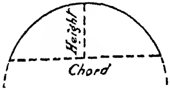
Area=The long and short diameters multiplied together and the result multiplied by ·7854.

Circle.

Area=Square of diameter multiplied by ·7854, *or* square of radius multiplied by 3·1416.

NOTE.—The area of a circle is equal to that of a triangle whose base and altitude are equal to the circle's circumference and radius.





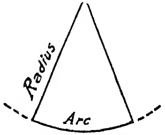
Segment of a Circle.

Area=The cube of the height divided by twice the length of the chord added to two-thirds of the product of chord and height *or* the area of the sector which has the same arc, less the area of the triangle formed by the radii and the chord.

NOTE.—When the segment is greater than a semi-circle, find the area of the circle and deduct the area of the smaller segment.

Sector of a Circle.

Area=Half the product of the arc multiplied by the radius, *or* length of arc multiplied by half the radius, *or* the number of degrees in the arc multiplied by the area of the circle and divided by 360.



Circumference of an Ellipse=Multiply half the sum of the two diameters by 3·1416.

Any figure bounded by right lines=Divide into triangles and take the sum of their areas.

Cubic capacity of a solid triangle=Area of triangle × depth.

" " *cone or pyramid*=Area of base × $\frac{1}{3}$ height.

Having determined the gross cubic space, it is usual to deduct from it, the space occupied by large solid objects in the room, such as beds, cupboards, etc. The available space for ventilation is arrived at, after making these deductions. Next proceed to examine the various openings for the inlet of fresh air and the exit of foul air. In ordinary natural ventilation as obtained in the City, the same openings will serve for entrance and exit of air. The points to be noted are, that the openings should be sufficiently large, sufficiently numerous, and placed at sufficient intervals so as to bring about an equable distribution of a proper quantity of air.

CHAPTER VI.

Food.

Food is necessary for the formation of new tissues for the repair and renewal of the wasted tissues and for the production of heat and energy. The diets of nations are influenced by varying circumstances such as availability, climate, habits and customs, economic conditions, occupation, etc. A defective diet retards development physically and mentally, lowers resistance and renders one more prone to infectious diseases, gives rise to certain deficiency diseases and affects health in a number of other ways. Food if clean, fresh, and wholesome ensures health and well-being but if unwholesome and contaminated gives rise to various diseases.

Man is, in practice, omnivorous; he, however, adopts such food as is suitable to the environments and the climatic conditions he lives in, and to the daily pursuits of his life, whether active or otherwise. Thus the inhabitants of extremely cold climates take large quantities of animal food with fats, as it serves a double purpose, nutritive and heat-producing. In temperate climates, other conditions prevail and the people adopt a food suited to the physiological requirements of a temperate climate. The food is of a mixed nature, consisting both of animal and vegetable products. In tropical climates the conditions are entirely changed; the temperature is such as not to demand a continuous supply of a heat-producer, and the land produces an abundance of vegetables, fruits, etc., which are more agreeable to taste and more easy of digestion.

Food may affect man adversely in several ways :—

(1) Animal parasites, *e.g.*, Trichinæ and Cysticerci.

(2) Pathogenic Bacteria, *e.g.*, Bacilli of the Salmonella group, B. Typhosus, Cholera, etc.

(3) Bacterial Toxins, *e.g.*, of B. Botulinus.

(4) Natural poisons in Mushrooms, Certain Fungi (Amanita Phalloides) and Fish.

(5) Special poisons, *e.g.*, Solanin in potatoes, Ergot in rye, Tyrotoxicon in milk.

(6) Idiosyncracy of certain persons to certain foods *e.g.*, eggs, tomatoes, &c., causing allergic symptoms.

(7) Poisons introduced from outside, *e.g.*, lead, arsenic copper.

(8) Over-eating or underfeeding.

(9) Defects in digestion and metabolism.

(10) Defects in the composition of diet, *e.g.*, excess or deficiency of proteins, carbohydrates, fats, or absence of Vitamins.

PHYSIOLOGICAL CHANGES—THE ALIMENTARY CANAL.

In the human system provision is made for the digestion of animal and vegetable proteins, starches or carbohydrates, and fats and oils. In the mouth, in the process of mastication and trituration, the food is intimately mixed with saliva which contains a ferment, "ptyalin," by the action of which starchy and farinaceous foods are dissolved and converted into soluble sugar compounds ready for assimilation and absorption. In the stomach, there is the gastric juice containing a ferment called "pepsin," which acts on protein compounds converting the same into soluble and easily absorbable forms called "peptones". The portions of food not digested in the stomach, pass into the intestine which receives secretions from two large and important glands, the liver and the pancreas.

The secretion of the liver is bile. By its action the animal fats and vegetable oils are emulsified and saponified, and ren-

dered easy of digestion. The pancreas supplies the pancreatic juice possessing peculiar properties which enable it to perform the functions of both the gastric juice and saliva. The action is due to the three ferments it contains, namely, (1) trypsin, (2) amylase and (3) lipase. Trypsin peptonises the unchanged proteins and splits the peptones up into amino-acids, *viz:* leucin, tyrosin and aspartic acid, crystalline nitrogenous substances very different from proteins. Trypsin is, in all respects, a more powerful ferment than pepsin: it reduces peptones into more easily absorbable products. Amylase or sugar-forming ferment changes starch into dextrin and maltose, just like ptyalin of saliva. Lipase or fat-splitting ferment splits up fats into glycerine and corresponding fatty acids; the latter acids unite with the alkalies of the pancreatic juice and bile and form soaps which emulsify and saponify fats and oils. As digestion proceeds, the food is reduced first to a sloppy condition and finally to a liquid state. This fluid is of a milky consistence and is called chyme; as it passes downwards it is absorbed by hair-like processes called villi, which project from the walls of the intestine, and from these it soon passes into the blood vessels with which the intestine is abundantly provided.

Foods may be divided into animal, vegetable, and mineral. Animal food includes meat, fish, eggs, milk and its products, animal fats and gelatin. Vegetables include cereals, pulses, roots and tubers, green vegetables, fruits and nuts, and vegetable oils. Minerals are derived from animal and plant foods and are mainly calcium, potassium, sodium, chlorine, iodine, magnesium, iron, sulphur, etc. Sodium Chloride and water, and dissolved salts are taken separately.

The food constituents may be classified into nitrogenous and non-nitrogenous. The former includes the Proteins, and the latter Carbohydrates, Fats and oils, mineral salts, vegetable acids, Vitamins and water.

Proteins include mostly all the organised nitrogenous substances which occur in animal or vegetable tissues. The proteins or albuminoids are highly complex salts composed approximately of 16% nitrogen, 54% carbon, 22% Oxygen, 7% Hydrogen, and 1% Sulphur. The proportion of N to C is in the ratio of 2 to 7.

In the digestive tract the proteins are hydrolysed by the digestive enzymes and split up into substances of progressively diminishing molecular size. The products in order of formation being (1) Metaproteins, (2) Proteoses, (3) Peptones, (4) Polypeptides and (5) Amino-acids.

The ultimate cleavage products of the proteins are therefore, the Amino-acids of which there are about seventeen, *e.g.*, Tryptophane, Histidin, Arginin, Lysin, Leucin, etc., all of them being indispensable constituents of an adequate diet, as it is from these that the body cells reconstruct the portions necessary for themselves. The proportion of Amino-acids vary in different proteins. The nutritive value of proteins will depend on the number and proportion of Amino-acids present. As the result of katabolic processes in the body, the proteins are finally broken down into CO_2, H_2O, H_2SO_4 (combined as sulphates), urea and creatinine which are excreted in urine and other excretions. Animal proteins are better than the vegetable. They have biologically a higher value, as they contain all the necessary Amino-acids and are easily digested. Casein contains all the Amino-acids necessary to build up tissue, hence milk is the best food. Meat, liver, eggs and a few seeds, *e.g.*, peas and beans also contain proteins of good quality but cereals do not contain all the Amino-acids necessary and tubers and vegetables still less. Proteins are necessary to build up the tissues and form the digestive and other fluids of the body, repair waste and yield energy in the form of heat and muscular power. Some of the decomposition products of the proteins are harmful to the system and are excreted. If an excess of meat be

taken, these waste products will not all be excreted and will accumulate, and the excretary organs will be overtaxed and derangement of the liver and kidneys will ensue. A diet of about 100 grams per day of protein is usually regarded as sufficient but Mc'cay found that the average Bengali only takes 39.5 grams protein.

Fats are the compounds of Glycerine and the fatty acids Palmitic, Stearic, Oleic, etc. They contain C, H & O, but no N, the O being less than is necessary to form water with H.

Fatty foods repair and renew the fatty tissue and yield energy and heat. The energy yielded by fat is more than twice that of an equal amount of Carbohydrate as it contains more C in the molecules.

Fats are taken as butter, fat of meat, fish oils, vegetable oils from nut and seeds (*e.g.* cotton seed oil, olive oil, etc.)

The fats of milk and eggs are specially rich in fat soluble Vitamin A, and Cod liver Oil has a good deal of antirachitic Vitamin D. Lard and vegetable oils are devoid of Vitamins.

Fats are stored in the connective tissue and serve as a reserve material for use when required as a source of energy.

Absence of fat in diet will give rise to mal-nutrition and possibly tuberculosis. If fats solely replace carbohydrates in a diet, or in conditions *e.g.*, Diabetes, in which the carbohydrate metabolism is deranged, acidosis and serious consequences may arise due to the defective oxidation of the fats in the absence of carbohydrates.

Carbohydrates are composed of C, H & O, the two latter being in the same proportion as in water.

The Carbohydrates can be divided into Monosaccharides, Diasaccharides, and Polysaccharides.

Monosaccharides.	*Diasaccharides.*	*Polysaccharides.*
($C_6H_{12}O_6$)	($C_{12}H_{22}O_{11}$)	($C_6H_{10}O_5$)n
		Starch+
Glucose+	Sucrose+	Glycogen+
Fructose—	Lactose+	Dextrin+
Galactose+	Maltose+	Inulin—
		Cellulose—

+ and — signs indicate dextro and lævo rotatory respectively as regards polarised light. Carbohydrates are taken in the form of cereals (rice, wheat, etc.) tubers (potatoes), sugars and juices of fruits, etc., and flesh (Glycogen). Carbohydrates are concerned with the production of animal-heat and energy, and the formation of new fatty tissues. They also maintain the proper reactions of the various body fluids.

Mineral Salts form one twenty-fifth part of the body. The most important elements are calcium, potassium, sodium, iron, phosphorus, magnesium, manganese, sulphur, chlorine and iodine.

Mineral Salts are builders of tissues and sources of potential energy. They help to keep the proper reactions of the body fluids. They are abundant in bones and teeth, and are also present in the blood, muscles and soft tissues. No single foodstuff, except milk, contains all the mineral salts in the right proportion needed for the body. Even milk is poor in iron.. Some foods, *e.g.*, meat, pulses, and cereals are rich in acid producing elements, whilst others *e.g.* leafy vegetables, roots, tubers and fruit, in the alkali producing. To maintain the proper reaction of the body fluids it is necessary, therefore, for cereal and meat eaters to have plenty of fruit and leafy vegetables. As mineral salts are usually soluble in water, in boiling vegetables and other foods, much of the salts will escape into the water which should, therefore, not be discarded. Mineral salts being principally present in the outer covering of cereals, polished rice, and white wheat flour contain very little mineral matter. Calcium is present in milk, eggs, pulses, fruits, and green vegetables, iron in beef, eggs, liver, spinach, pulses and cereals, manganese in wheat, and phosphorus in potatoes, eggs and milk, etc. Deficiency of mineral salts in diet will give rise to rickets, bad teeth, anæmia, constipation, gastric troubles and may affect the alkalinity of the blood.

Vegetable acids of fruits and vegetables have a beneficial effect on the well-being of the individual. They occur as

salts of citric, tartaric, malic, oxalic, lactic and acetic acids and are converted into carbonates which produce the alkalinity, which is a necessary character of the normal constitution of blood and other fluids of the body; when deficient or absent from the food, a state of malnutrition occurs which, if continued, finally developes into scurvy.

Water.—In the human system the percentage of water to the body weight is about 62 and the body loses about 100 ounces daily. The necessity for water is therefore obvious; it must compensate for the losses caused by the excretory organs and skin. Its presence is a necessary condition for the occurrence of chemical changes in the human system. It is valuable for the dilution and solution of solid foods, whereby they are easily digested and assimilated. Moreover, it is a necessary constituent of all body tissues.

The quantity required by each individual varies according *to the bodily labour and the temperature* he lives in. The more the functional activity of the body organs, the more is the need of water.

VITAMINS.

Clinical and experimental observations during recent years have given us an insight into the influence of certain "accessory food factors" present in minute quantities in natural food, which are indispensable for the normal growth and health of an animal. Chemists have analysed the various foods and estimated the percentage of the four basal constituents, *viz:* protein, carbohydrates, fats and mineral salts, and have expressed the energy value of foods in calories. Scientists have gone a step further and have proved that in addition to being supplied with food which contains the necessary energy value and the four basal constituents, animals require certain other substances, which have not as yet been chemically isolated, but which though present in very minute amount in natural foods, yet play a very important role in nutrition. Food devoid of these constituents will

wholly fail to promote growth and health, and grave symptoms of actual disease may supervene with the continuous use of such a diet.

Scientists have attempted to replace natural foods by artificial diets containing pure protein, carbohydrates, fats and mineral salts obtained by extracting them by chemical processes from natural foodstuffs and purifying them. Hopkins for instance, fed young rats on caseinogen (protein). lard (fat), starch and cane-sugar (carbohydrates) and inorganic salts and adjusted their amounts so as to supply an adequate and well balanced supply of the necessary food units. Growth invariably ceased after a comparatively short period and the rats died. To another batch of rats, in addition to this basal ration of purified foodstuffs mentioned above, he allowed a daily amount of raw milk and the result was normal and continued growth.

The great efficiency of natural over artificial foods proves that some unidentified substances are present in natural products, which are destroyed in the process of preparation but which are essential for growth and maintenance of health. These accessory food factors are now called Vitamins. The Vitamins are certainly chemical entities present in minute quantities in certain foods and though it has not been possible to isolate them at present in a state of purity, much information has been gathered on experimental evidence as regards their origin, distribution and their physiological and chemical properties. In the present state of our knowledge the following Vitamins have been identified, *viz:* Vitamins A, B, C, D, & E. A shortage of these in food will cause certain diseases *e.g.* Rickets, Xerophthamia, Beri-Beri, Scurvy, Pellagra, &c. and hence they have been called "Deficiency Diseases". Vitamins also have an important bearing on resistance and immunity, and a deficiency will cause increased susceptibility to certain infections particularly of the respiratory and digestive tracts.

Vitamin A, anti-xerophthalmic or fat soluble A—is present in milk, butter, egg yolk, fish fat, cod liver oil, fish roe, liver, kidney, mutton and other animal fat, and in leaves of plants, and sprouted pulses and is absent in white flour, polished rice, and vegetable product. It is formed by the action of sunlight on the green leaves of plants, and animals living on plants store it in their milk, fat, and glandular organs. It is not soluble in water but is so in various solvents for fats *e.g.*, Ether and Petroleum. It is not stable at high temperatures and oxidation processes destroy it. It is not destroyed by ordinary cooking, but if cooking is prolonged and the food exposed to the air whilst cooking, Vitamin A will be destroyed. Vitamin A is needed for growth and repair, to maintain the proper composition of the blood and to protect one from infectious diseases. A complete lack of Vitamin A will cause cessation of growth. The specific effect of a lack of a sufficient amount of this Vitamin is the development of Xerophthalmia (inflammation of the eyes) which may lead to blindness. There will be also a tendency to infections, of the intestinal and respiratory tracts.

Vitamin B or water soluble B is resistant to heat. It has been proved to be separable into two or more components which suggests its multiple nature. It is supposed to include Vitamin B_1 anti-nueritic (anti-beri beri) which is the more heat labile, and Vitamin B_2 (P. P. or Pellagra preventive) which is the more heat stable. Besides these, Vitamin B_3 and B_5 necessary for normal nutrition in pigeons, Vitamin B_4 for rats and factor Y have been identified. Vitamin B_1 is found widely distributed in all natural foodstuffs except honey, egg-white and endosperms of cereals. It is abundant in cereals (wheat, rice, etc.), pulses (peas, beans, etc.), vegetables (water-cresses, lettuce, carrots, etc.), eggs, liver and yeast. The embryo and outer covering of cereals are the largest depositories, the endosperm being entirely deficient. Milk, meat and fish are poor in Vitamin B_1.

Vitamin B_2 has been found to accompany Vitamin B_1 in foodstuffs, but their quantitative distribution varies, meat and milk being richer in B_2 and egg yolk, green vegetables and wheat embryo in B_1. Hen's white of an egg contains Vitamin B_2 but is devoid of Vitamin B_1.

Vitamin B_1 in addition to affording protection against polyneuritis (Beri-Beri) is an essential factor for the normal growth and health of the body. A deficiency of Vitamin B_1 may cause loss of appetite, inanition, anæmia, malnutrition of the nervous system and cardiovascular depression. The process of milling and parboiling rice removes the Vitamin B_1. The use of polished rice, *i.e.* rice deprived of its outer coverings has been proved to be the cause of Beri Beri, and when the polishings are added, or when whole rice is used, the disease is cured.

Deficiency of Vitamin B_2 (anti-dermatitis or P. P. Vitamin) is associated with skin lesions, *e.g.* Pellagra which causes dermatitis on the face and hands and inflammation of the alimentary tract. Pellagra has been attributed by Funk to be due to the polishing of maize which removes the husk or outer coat.

Cooking *e.g.* boiling of vegetables, or stewing of meat does not as a rule affect the Vitamin B except through the diffusion of the Vitamin into the cooking water. The high temperature required for canning of foodstuffs may however seriously affect Vitamin B. Drying of foodstuffs which have a high water content will increase the amount of Vitamin B relative to bulk.

Vitamin C—antiscorbutic Vitamin or water soluble C, is, of all the Vitamins, the most easily destroyed by heat, drying, oxidation, &c. It is soluble in water and alcohol. Cooked food has very little of Vitamin C and dried foods none. Continued use of tinned food without any fresh fruit and vegetables will give rise to scurvy.

Vitamin C is necessary to help the other Vitamins in building the body specially the teeth and bones, to keep the blood pure and of proper composition, to keep the bowels regular, and to resist infections.

Vitamin C is present in fruit specially oranges, lemons, tomatoes, fresh vegetables, and sprouted peas or beans. It is absent in lean meat, cereals, vegetable and animal oils, dried vegetables, fruits, nuts, tinned milk, dried milk, sugar and honey.

Vitamin D—antirachitic Vitamin is present in all animal fats (except lard) *e.g.* milk, butter, yolk of egg, fish oils, *e.g.* cod liver oil, and in some fish fat. A little is present in cocoanut oil and peanut oil but not in most vegetable oils. It is abundant in cod liver oil. It is a fat soluble vitamin and is resistent to heat. Deficiency of this Vitamin will cause Rickets and Osteomalacia. Children whose food is deficient in Vitamin D will be cross, nervous and restless. Their bones will be soft, their legs deformed, their spines crooked, their muscles flabby, their teeth decayed, and blood poor. They may be prone to convulsions, and will be liable to catch colds and diseases of the respiratory organs. Foods exposed to ultraviolet light are known as irradiated foods and acquire antirachitic properties. Rickets can be cured by cod liver oil, and a daily exposure to sun-light which inhibits the bony changes due to a diet deficient in Vitamin D, or by the radiation of the Mercury Vapour Quartz lamp.

Vitamin E—anti-sterility Vitamin is present in green vegetables, specially fresh green lettuce leaves. The oil extracted from wheat germ is the most potent known source of Vitamin E. Deficiency of this Vitamin produces different results in male and female animals. In male rats and mice, it produces a gradual loss of reproductive power leading to complete and incurable sterility (Evans & Burn 1927). In the females, however, fertilisation of Ova and their implantation take place without any difficulty but the *fœtuses* die in the

Uterus and are resorbed. Unlike that of the male, sterility in the female is amenable to treatment with Vitamin E.

The part played by Vitamin E in the problems of human fertility are being investigated at present. The only results as yet published are those of Vogt-Moller (1931). Two women who had experienced 4 and 5 previous miscarriages were treated with wheat-germ oil. In both cases, a successful pregnancy occurred.

DIET.

Dietaries of individuals differ according to the nature of their occupation, physical labour and energy expended, body-weight and surface area, sex, age, climate, availability and cost of food, taste and desires, religious prejudices, social customs, etc. Various physiologists differ in the quality and quantity of food they recommend under varying circumstances. Energy is necessary for (1) the internal mechanical work of the body which is required for the maintenance of circulation, respiration, digestion, etc., (2) external mechanical work expended in movement or locomotion, lifting and carrying weights, etc. The internal mechanical work is performed mechanically by the heart and the organs and is estimated at 260 foot tons, *i.e.*, " it is equivalent to the work which a man does who raises 260 tons to the height of one foot ".

Dietaries are therefore calculated according as the diet is necessary for :—

(1) Subsistence, just sufficient for the internal mechanical work of the body.

(2) Ordinary work (consumption of energy equivalent to 300 foot tons).

(3) Laborious or hard work—to compensate a work equivalent to 450 to 500 foot tons.

The theoretical amount of heat production or energy produced on the combustion of 1 gramme of each of the three principal constituents of food with oxygen are as follows :—

Proteins ..	..= 4.1 calories
Carbohydrates	..= 4.1 ,,
Fats ..	..= 9.3 ,,

It will be seen that $2\frac{1}{4}$ parts of carbohydrates supply as many calories as a 1 part of fat.

The subsistence diet for a man of average weight and size (about 150 lbs.) should give about 2700 calories, and for light, moderate and hard work 3000, 3500, and 4000 or more calories respectively. (A calorie is the amount of heat necessary to raise 1 kilogram of water through 1° C). For an average working class Indian weighing 9 stones, about 2500 calories would be required, rising to 3500 calories according to the part of India and amount of work he has to do. An Indian woman requires four-fifths of this amount or 2000 to 2800 calories per day.

A standard diet suitable for an Indian of average build and weight, doing moderate work should be approximately :—

Proteins 90 to 100 grams (3 to $3\frac{1}{2}$ oz.).
Carbohydrates 360 to 450 grams (12 to 16 ozs.).
Fat 80 to 90 grams (3 ozs.).
Salts 20 grams.
The energy value of the above will be about 3000 calories.

About 10 per cent more calories will have to be given on account of the incomplete absorption of constituents and another 10 per cent on account of waste and loss during cooking.

If one part of fat is equivalent to $2\frac{1}{4}$ of carbohydrates it will be seen that the ratio of protein to carbohydrates and fat is 1 to 6. This is the nutritive ratio and represents the proportion which the building material of the diet (protein)

bears to the energy yielding constituents (fat and carbohydrates). By means of chemical analysis the relative proportions of proteins, carbohydrates and fats in every article of food have been determined and the potential calorific value have been worked. Thus one ounce of rice contains 2.3 grams proteins, 22.3 grams carbohydrates and 0.85 grams fat. The proteins will yield therefore 2.3×4.1 or 9.4 calories, the carbohydrates 22.3×4.1 or 91.4 calories, and fats 0.085×9.3 or 7.9 calories, the total being 108.7 calories from an ounce of rice. Dietaries of the proper kind and amount of food can, therefore, be drawn up to contain the necessary amount of calories, and the essential proportion of the three important constituents.

Kenwood gives the following table compiled from various sources showing the amount of food constituents required for ordinary and laborious work :—

——	Ordinary Work.		Laborious Work.	
	Oz. av.	Grammes.	Oz. av.	Grammes
Proteins	4.5	127	6.5	184
Fats	3.5	99	4.0	113
Carbohydrates	14.0	397	17.0	482
Salts	1.0	28	1.3	37
Total water-free food	23.0	651	28.8	816
Calories	3069		3781	

The above figures represent dry food, but as the latter usually contains 50 to 60 per cent. of water the amount should be doubled in actual practice. The proportion of nitrogen to carbon in the best diets is 1 to 15 and as the ratio of N to C in protein is 1 to 3.5 the extra carbon can be obtained from fats and carbohydrates.

Proteins are necessary for the building up and repairing of tissues, and an intimate connection exists between the

physical and mental development and well-being of a people and the amount of animal proteins they consume.

Carbohydrates and fats are spoken of as fuel foods as they contain great stores of energy. The carbohydrates are the greatest sparers of protein as they produce energy and heat and thus allow the proteins to concentrate on the building up and repair of tissues. They are easy to digest but when taken in bulk they throw a great burden on the organs of digestion. Fats help to decrease the amount of carbohydrates and thus relieve the intestines by bringing the diet within a reasonable compass. They give greater staying power but are more slowly digested.

Chittendon as the result of experiments on athletes, soldiers, professional men, etc., held that nitrogenous equilibrium, health and efficiency could be maintained on a diet containing only half of the amount of protein usually advocated, without increasing the non-nitrogenous element. The proportion of protein calories to the total calories according to Voit and Atwater is 3 : 20 but according to Chittendon is 2 : 25. But his conclusions are open to doubt for the following reasons :—

(1) A reduction in the amount of protein may be borne for a few months but if continued for years may lower the resistence of an individual to disease.

(2) In case hard work has to be done, more fat and carbohydrates than can be digested will have to be taken.

(3) It will render a person unable to assimilate in future more protein in cases of wasting diseases and convalescence.

(4) There may be a gradual waste of nitrogenous substances from the body if there is a lack of protein.

There are various factors which will influence the amount and quality of the food required.

As mentioned before a man at rest will require much less food than one who is doing much muscular work. Compared with diet for muscular work, diet for a man doing mental work should be smaller. The carbohydrates and fat should be reduced rather than the proteins. The latter stimulate mental work and should be derived from animal foods as these are more digestible and compact.

Heavier the body more food will be required, but a muscular man of the same weight will need more than one whose weight is due to excess of fat, or heavy bones.

A thin and tall man will require more food than a short and fat one of the same weight, as the former has a larger body-surface and the loss of heat will be greater. The surface area of average man is $21\frac{1}{2}$ sq. feet, and calculated on this basis about 130 calories must be obtained per square foot. Women require 1/6 less food than men, as they not only weigh less, but have relatively more fat and less of muscle.

Children relatively to their weight require more food as they have a larger surface in proportion to their bulk and moreover they are growing. A child of eight will require little more than half, and a child of fourteen as much as an adult of the same sex. After 50, the food should be less, and old persons require less protein and carbohydrates and little more fat than middle aged persons. More food is required in cold climate than in temperate and in temperate than in hot climate. In hot weather the appetite is lessened and less food is taken. In very cold climate, the amount of food should be increased and in hot, the animal food should be diminished and the vegetable food increased.

A well-balanced diet must not merely have the required number of calories but also the adequate proportion of the various elements of food, *viz.*, proteins with the essential amino-acids, carbohydrates and fats, mineral salts and vitamins.

Every food is usually rich in one or two particular items but very deficient in others. Diets will have, therefore, to be judiciously planned out containing a variety of foodstuffs. It is well-known that one should not take too much of any one kind of food. "Health depends upon a judiciously mixed dietary, a dietary regulated on the principle of moderation."

In nature, there does not exist any complete food having the adequate proportions of a mixed diet. Cereals form the staple food of Indians but they cannot be used as the sole source of nutriment as they are deficient in proteins, fats; certain mineral salts, and Vitamins A, C, and D. Wheat is comparatively rich in protein, but the proteins of all cereals are much less suitable than those of animal food. Polished rice and white wheat flour are devoid of Vitamin B. Pulses are rich in proteins but the latter are not of the same value as those of animal foods. They are useful in supplementing cereals in diet but more than 4 ozs. cannot be digested daily by anyone. They are poor in certain mineral elements and also in Vitamins A and C except in the case of sprouted pulses.

Meat has the most suitable proteins but is deficient in carbohydrates, Vitamins and certain mineral salts *e.g.*, calcium. Milk, the ideal food of infants, is not a complete food in the sense required by an adult, in as much as it is poor in iron and contains no starch, for the digestion of which two specific ferments are provided in the human system, namely, ptyalin and pancreatic amylase. It contains a large proportion of water and relatively large proportion of fats in comparision to the carbohydrates and proteins. Eggs have all the necessary nutrients for an adult but are deficient in carbohydrates and hence cannot be a complete and perfect food.

Leafy vegetables and fruits are useful on account of their mineral salts and vitamins, and tubers are rich in carbohydrates ; but they are all deficient in proteids and fat.

Mineral salts are also necessary, and an ordinary mixed diet contains about 20 grammes of mineral matter exclusive of salts added to the food. Man also requires about $2\frac{1}{3}$ pints of water every day for building up the tissues.

It will be seen, therefore, that man cannot depend on any one foodstuff and that a mixed diet is most suitable.

A combination of the following groups of foodstuffs are important in the drawing up of diet :—

(1) Milk and milk-products, (2) flesh of animals, (3) animal fats, (4) vegetable oils, (5) cereal grains, (6) tuber and root vegetables of all kinds, (7) peas and beans, (8) nuts and seeds, (9) leafy vegetables, (10) fruits and berries.

A diet which consists essentially of cereals and pulses, must be supplemented by milk, or meat, animal fat, leafy vegetables and fruits to make up for deficiencies of proteins, mineral salts and Vitamins.

An inquiry into the budgets of the working class people of Bombay, revealed that the diet of an adult man was composed of about Proteins 60 grammes, carbohydrates 500, fats 32, equivalent to 2,563 calories. The ratio of calories of proteins to total calories was 1 : 10. It was lacking very much in proteins and vitamins, the bulk of the food being cereals chiefly rice (85.9%) and only 0.59 oz. of milk and 0.5 oz. of animal flesh was consumed daily.

Compared with the industrial worker, the daily diet in the Bombay Jails consists of 24 ozs. cereals, 4 ozs. pulses, 0.5 oz. meat, 0.6 oz. salt, 0.02 oz. oils and 8 ozs. vegetables besides condiments and it will be seen that criminals in Jails are well treated as regards diet.

In drawing up a diet the following suggestions should be borne in mind :—

(1) An extra allowance of 10 to 15 per cent. should be made for those doing very hard work.

(2) 10 per cent. should be added on account of waste.

(3) Age and sex considerations, as women, children and old people consume less. Lusk's co-efficients are :—

Age & Sex.	*Equivalent Adult Male.*
Male over 14	1.00 adult male.
Female over 14	.83 ,,
Child 10—14	.83 ,,
Child 6—10	.70 ,,
Child under 6	.50 ,,

(4) Not less than one-third of proteins should be from animal sources.

(5) A variety of cereals is preferable to only one, *e.g.* rice, wheat and bajri.

(6) Pulses (Dhals) should not be more than 4 ozs.

(7) Half of the fat should be from animal sources and if fat is not well digested it may be reduced to 50 grams and more carbohydrates taken.

(8) Vegetables and fruits should be four times the weight of meat and Dhal.

(9) In very cold climates the amount of fat should be increased.

The following table gives a well-balanced diet recommended by Dr. Ghosh for an average man doing medium work. It should be supplemented by fruits, and pure vegetarians may replace fish or meat by 4 ozs. of milk :—

——	Protein.	C.H.	Fat.	Calories.
Rice 8 oz.	16	204	2	832
Atta 6 oz.	21	120	4	612
Dal 4 ozs.	29	64	3	400
Oil or Ghee 3 oz.	..	..	87	783
Fish 4 oz.	20	..	8	160
Vegetables 6 oz.	2	6	..	30
Milk 12 oz.	12	14	12	210
Total in grammes	100	408	116	3,027

Vegetarian Diet.—The proteins from the animal kingdom have a higher biological value than those from the vegetable, but the fats are as good. The disadvantage of a pure vegetarian diet is that the bulk of the food is enormously increased so as to supply the necessary proportion of proteins, carbohydrates and fats, which greatly interferes with digestion and absorption. This causes a disorder of the stomach and intestines and the increased distension of the alimentary canal gives the vegetarian a pendulous abdomen. Much of the protein is not digested and the physical development and nutrition thereby suffer. More blood and energy are required for the digestive tract and less goes to the brain, and the mental capacity is diminished. The large amount of water renders the tissues more flabby.

Over-feeding.—When excess of food is taken, fermentative and putrefactive changes take place, foul smelling gases containing sulphur and phosphorus are formed and undigested muscular fibres, fat and starch cells are detected microscopically in excess in the fæces. The digestive apparatus is overworked, the stomach and bowels are distended, the liver becomes congested, the tongue heavily coated and the products of putrefaction are absorbed into the system causing langour, headache, and fever. Over-eating also favours high blood pressure and arteriosclerosis and diarrhœa and dyspepsia. Chronic over-eating and over-drinking will cause obesity with fatty heart and degenerative changes. Excess of carbohydrates causes fermentation and may give rise to diabetes, excess of fat will produce acidosis, and excess of protein putrefactive changes and irritation of the kidneys.

Under-feeding will cause a large diminution in the working efficiency of a person, and will retard growth. Chronic under-feeding is worse than over-feeding. There will be loss of weight, anæmia, specially in children and debility. Malnutrition in children is due to a faulty diet, too much of carbohydrates without a due proportion of protein. Dr. C.

Mann proved experimentally that children put on milk increased not only in weight and height but showed generally improved health and "spirit."

During the last war, many soldiers who were underfed for a long period showed symptoms of dropsy, slow pulse, low blood-pressure and polyuria.

Under-feeding will lower the resistance to disease specially tuberculosis, scrofula, relapsing fever, typhus, etc. An ill-balanced diet, *i.e.*, one deficient in some nutritive constituent will cause ill-effects.

Certain people can fast for some weeks without taking any food except water.

MEAT.

Meat is very largely used by man as an article of diet. The flesh of sheep, cows, pigs, goats, poultry and game is principally used but horses, donkeys, dogs, and cats are also slaughtered for human food. Animals that live on plant life are usually selected whilst the flesh of carnivora is rejected.

Meat consists of muscle fibres held together by connective tissue, associated with which are also blood vessels, nerves, lymphatics, and adipose tissue. The toughness of meat is due to the muscle fibre and connective tissue. In young and domesticated animals the meat is more tender than in old and wild ones. In meat Glycogen and fat are stored as reserve foods. During life meat is alkaline in reaction but after death rigor mortis sets in and Sarcolatic acid is formed which gives it an acid reaction, rendering it soft.

Animal tissues may be differentiated into (1) Glandular organs *e.g.* liver, kidneys, etc. (2) Muscular tissues. Both are rich in amino-acids. The former is rich in Vitamins A & B, and the latter deficient. Meat is very nutritive, as it contains all the amino-acids in the proportion necessary to build tissues. But as it is deficient in mineral salts and Vitamins

it alone cannot maintain growth and nutrition. The following is the percentage composition of Beef :—

Water 76·7 ; Protein 18·8 ; Fat 2·2 ; Carbohydrates 0·6 ; Salts 1·7.

Among the important proteins in meat are Syntonin, Myosin, Muscle albumin, and Serum albumin. The extractives are Creatin, Creatinine, Xanthin, Hypo-xanthin; the Carbohydrates include small quantities of Inosite and Glycogen.

The nutritive properties of meat are due to the proteins and fat. The extractives in the meat juices give a flavour and taste to the meat and act as stimulants, but are not nutritive.

Bones contain 24% protein, 11% fat, 48% ash and a nourishing soup can be prepared by boiling bones.

The diseases which are usually transmitted to man by meat are :—

(1) Parasitic Diseases due to Tænia Solium, T. Mediocanellata, Trichna Spiralis, and Distoma Hepatica.

(2) Food infections due to B. Enteritidis of Gaertner and B. Botulinus.

(3) Tuberculosis, Anthrax.

There are several diseases of animals, which are transmissible to man through the use of unsound meat but usually they are not conveyed thus on account of the prevention of sale of unsound meat and the safeguard of cooking.

FISH.

Fish is extensively eaten in the tropical climates, and along the coast, where fish abounds, it forms one of the chief constituents in the dietaries of the people. Fish must be fresh and must be eaten as early as possible after being caught. In hot climates fish rapidly loses its freshness. Stale or partly decomposing fish is poisonous. It produces symptoms of Gastro-Enteritis. Fresh fish is always firm and stiff : any

drooping of the tail indicates staleness. Fresh fish has the slime clear and not discoloured, the scales are full and not dull or damaged, the eyes bright and not sunken and dull, the gills bright and red. If old, stale or starting to decompose, pressure between the finger and thumb produces an indentation and may separate the skin from the flesh. Fish is in perfect condition just before spawning and is then said to be "in season;" during the process of spawning it becomes poor and thin and is "out of season." The flavour of fish depends upon the quantity of fat it contains and is also influenced by the food it takes; carnivorous fish have a finer flavour than those which feed on vegetable food; the former generally dwell in the sea and running streams, while the latter in muddy and stagnant waters.

All stale or decomposing fish must be forthwith condemned. Fish is "cured" by salting and drying or by smoking. The entrails are always removed. The amount of nourishment in any given fish is not perceptibly affected by these processes; and "cured" fish may be reckoned as simply equivalent to fresh fish. The industry of salting and drying fish is lucrative, and the fisherfolk of coasting towns are engaged extensively in this trade. Unless fish is properly salted and dried by exposure to the sun, it is liable to decompose. Dried fish, with rice, forms the staple diet of the poorer classes in India. The "Bombay duck," commonly called "bombla" or "bombil," requires special mention. It abounds along the Bombay and Gujerat coasts. It is eaten fresh, but more frequently salted and dried. The fresh fish is sometimes poisonous and produces symptoms of acute Gastro-Enteritis but the "cured" variety is extensively eaten; both the rich and poor indulge in it. If not properly cured, it is liable to decompose and produce Gastro-Enteritis. If fish is caught in spawning season, the roe is taken out and salted and dried; for domestic use it is pickled and used as a dainty.

Fish is also preserved in oil in tins in India. On the Malabar coasts sardines abound and European companies have

established factories for the tinning and exportation of sardine. The Indian mackerel is salted and smoked and exported to other countries. The fish is said to be poisonous during spawning season.

The nutritive properties of fish are the same as meat. Fish is poor in vitamins like meat but the liver oils from fish *e.g.* Cod-liver oil, have excellent antirachitic properties due to the large store of Vitamin D.

Some fish normally contain substances toxic to man *e.g.* various species of tetrodon and diodon. In Japan, the Fugu has often given fatal poisoning and in the Indian Ocean Anchovy Bellasa and the Mellite. Fish poisoning is sometimes due to the toxin of an anaerobe akin to B. Botulinus. Bacterial poisoning may arise from eating raw fish. B. Ichthyismus has been isolated from fish causing poisoning of the nervous system. The animal parasites found are Dibothriocephalus Latus and Paragonimus Westermanni.

SHELL FISH.

Shell fish, scientifically speaking, are not fish at all; they belong to the order of molluscs and crustaceans. Molluscs include oysters, mussels, clams, cockles, whelks; and the crustaceans include crabs, lobsters, prawns, shrimps, etc. Of the first group oysters and mussels are in great demand; of the second group, all the four mentioned are sought for.

Oysters and mussels are generally eaten raw. Oysters, when fresh and coming from a reliable bed, are easily digestible and are reckoned a dainty, but when they are collected from a bed to which sewage gains access, they are apt to be actively poisonous, producing symptoms of severe Gastro-Enteritis. Oysters may contain specific pathogenic germs gaining access to them from sewage contamination. They have been known to contain Eberth's (Typhoid) bacillus, and to occasion local outbreaks of Enteric when they happen to come from contaminated beds, and the causation has been conclusively traced to this infection. Besides Eberth's,

Bacillus Coli and Bacillus Enteridis Sporogenes have been found in oysters from polluted beds. Deep sea-water oysters are free from these germs and, therefore, perfectly harmless. Under certain circumstances, oysters are able to transmit the infection of Cholera. If there be any suspicion that an oyster was grown in a contaminated bed, it is best to discard it; the bacillus lives both in sea-water and within the shell of the oyster. It has, however, been recently shown by scientists that oysters, mussels and cockles have the power of clearing themselves of infected germs partly by discharging them and partly by directly devitalising the microbe. Therefore, oysters coming from suspected waters should be deposited in pure water for a time before consumption, but it is best to eschew them altogether, unless eaten properly cooked. The above remarks also apply to mussels and cockles. Experiments have shown that Bacillus Coli and Bacillus Enteridis Sporogenes are invariably found in these fish, especially in those coming from contaminated waters. These should be eaten properly cooked. The crustaceans, crabs, lobsters, prawns and shrimps should always be purchased alive and kept alive until the time of cooking, because their flesh decomposes very rapidly and, when only slightly tainted, may produce disastrous results. Even when perfectly fresh, they are found to disagree with many people and give rise to minor disorders. Shell fish is generally said to produce "Urticaria." Mussels are particularly liable to be toxic. They suffer from enlargement of liver, wherein is produced an alkaloid (mitilotoxin) which produces in man symptoms like those of curare poisoning. Mussels in this condition are, even if stewed, poisonous.

Mussels should be tested by shaking them up in a bag; if they rattle and the shells open up, they should be condemned. Cockles, when bad are found on opening the shell, to be thin and when squeezed no liquid squirts from them. Crabs and lobsters should be examined under the apron and tail to see if they are discoloured. Crabs which after boiling are wet and sticky under the large claws are unfit for food.

EGGS.

Eggs are largely used everywhere as an article of diet. Not only hens' eggs, but eggs of ducks, geese, turkeys, turtles, guinea fowls, etc., and fish (fish roe) are used. If a fresh egg be held before a bright light, it will be more transparent at the centre and the air space at the larger end and the moveable yolk will be discernible. Stale eggs are transparent at their upper extremities. Any opaque spots should condemn an egg.

If a fresh egg be placed in a solution of 2 ounces of salt in a pint of water it will sink, whereas a stale one will float.

An ordinary egg contains shell 12% (calcium carbonate), white 58% and yolk 30%.

The contents of an ordinary hen's egg weigh about 1½ ounces and contain 3.79 grammes proteins, 3.97 grammes fat and yield 42 calories per ounce.

The percentage composition of the white and yolk of hen's egg is as follows :—(Hutchison.)

	Water.	*Proteins.*	*Fat.*	*Extractives.*	*Mineral Matter.*
White ..	85.7	12.6	0.25	..	0.59
Yolk ..	50.9	16.2	31.75	0.13	1.09

The composition of eggs as compared with lean beef is as follows :—(Tibbles.)

	Egg.	Beef.
Water ..	73.7	70.88
Protein ..	14.8	22.51
Fat ..	10.5	4.52
Extractive ..	..	0.86
Ash ..	1.0	1.32

Eggs are very nutritious and form a complete food capable of supplying all the chemical constituents for the formation of a chick. It cannot be used, however, by man as a sole source of nutriment. Eggs contain less calcium salts

and only a trace of sugar as compared with milk. The proteins in eggs like milk are of a high biological value containing phosphorus. Phosphorised fats (lecithin) are abundant in eggs.

The white of an egg contains egg albumin, and smaller amounts of egg globulin and ovomucoid. The yolk contains a phospho-protein called Vitellin. The white of the egg like milk contains Vitamin A and the yolk Vitamins A & D. The most important of the mineral constituents are phosphoric acid, lime and iron. Eggs are not sterile but contain bacteria which have doubtless gained entrance while in the oviduct. Eggs, however, do not convey any disease to man but do cause the development of putrefactive organisms in the intestines.

Eggs do not agree with certain people who have an idiosyncrasy for them, allergic symptoms *e.g.* urticaria syncope, vomiting and coma being produced. They could be cured, however, of this by immunising them with repeated doses of very small quantities. Eggs can be preserved by drying, and coating with wax, gum, oil, or placing in saw-dust to exclude air.

Dried eggs.—Eggs are broken and the contents mixed and dried in revolving drums. The substance of the eggs forms a skin on the cylinder which is removed and powdered. They keep well and retain the nutritive properties of the original egg.

Liquid eggs are contents of eggs mixed and preserved by the addition of large amount of Boric Acid. They are exported from China.

VEGETABLE FOODS (CEREALS.)

The cereal grains *e.g.* wheat, rice, bajri, etc. are our cheapest and chief sources of carbohydrates and all are about equally good in supplying energy. The cereal grains used by the different races in India are those which grow best in the country where they live. The inhabitants of the Western Ghats, for instance, consume more jawari and bajri

the Konkanis more rice, and the Sikhs and Punjabis in the north more wheat.

Wheat is comparatively rich in protein but all the cereals contain proteins of a less suitable kind, as they are not absorbed from the intestine to the same extent as animal proteins. Wheat is poor in fat while maize and barley, are rich. Rice contains most starch and is poorest in nitrogen and fats. Cereals are deficient in Vitamins A, C & D, and certain mineral salts. They contain Vitamins B & E, but polished rice and white wheat flour are devoid of them and mineral salts. One therefore, cannot live on cereals alone as they do not contain in sufficient quantity all the constituents of food we require. Cereals are good as a diet but they cannot be the only food and must be supplemented by enough milk and milk products, pulses, green or leafy vegetables and fruit. It is a very good plan to have a variety of cereals, *e.g.* rice, wheat, bajri, rather than one alone.

McCarrison has proved that whole wheat has a much higher nutritive value than whole rice, due to its containing an excess of proteins, larger vitamin content, and the presence of manganese which stimulates growth. He ascribes the superior physic of the northern races of India (Sikhs and Punjabis) to wheat eating with the addition of milk and milk products, green vegetables, fruit, and occasionally meat and advocates such a diet for the people of India. In the case of rice not only is whole rice much inferior but the practice of parboiling, milling, polishing and washing to which it is subjected prior to consumption causes loss of Vitamins and mineral salts.

Cereals are the complete fruits (grain or caryopsis) of the plants of the natural order " Graminaceæ." Speaking generally rice and maize are the produce of hot climates, barley and rye of cold climates, while wheat is extensively grown in both climates. Cereals contain a very large proportion of starch, above 70 per cent. of the grain, while the albuminoid or pro-

teid material differs in different cereals, ranging for 6.5 to 18 per cent. Vegetable oil or fat exists to a very small amount, and salts represented by alkaline and earthy phosphates, although very small, are relatively large and important as nutritive substances ; it has also been observed that the larger the percentage of proteid matter, the larger is the proportion of these phosphates.

Wheat is the fruit-grain (seed) of the plant Triticum Sativa, sub-order Hordeæ of the Graminacæ. It is grown all over the world. In India it thrives best where rice does not grow ; it does not grow in districts along the coast where rice abounds.

Indian wheat grain is not uniform in consistence and size but the variations are in the relative proportions of starch and nitrogenous substances and the change in mineral salts and oils is infinitesimal. The albuminoid material varies according to the seed from 12 to 18 per cent., and there is correlative reduction in starch, about 6 per cent., which is not striking, as the reduction is small having regard to the large percentage of starch in wheat grain (about 70 per cent.)

Indian wheat is of two varieties, the white and the red; the former is rather soft and has an opaque kernel or endosperm and the latter a red and translucent one, which indicates a large percentage of nitrogenous matter or albuminoids, while the former has a higher percentage of starch. The average composition of Indian grown wheat is—

Water	12.5	per cent.
Albuminoids	13.5	,,
Starch	68.4	,,
Oil	1.2	,,
Fibre	2.7	,,
Ash..	1.7	,,

The legal standard in Bombay for wheat flour is that it should not contain more than 2 per cent. of ash or less than 8 per cent. of gluten.

The nitrogenous matter or albuminoid in wheat consists of different substances: gliadin, mucin and fibrin constitute the crude 'gluten.' This substance may be readily obtained by kneading the flour with water and subsequently washing away the starch and soluble matters, which are two: albumin and cerealin. Gliadin renders the gluten tenacious, stringy and elastic, and this cohesive property renders wheat flour so adapted for making bread. Cerealin has properties akin to diastase, converting starch into dextrin and maltose. The carbo-hydrates are chiefly starch with a very small amount of dextrin and cellulose. The salts are principally phosphates of potash and magnesia; the nutrient ratio of wheat is 1 : 5, and nutrient value 84.

Wheat flour is extensively used in Indian dietaries. The old process, which even to-day obtains in mofussil towns and villages where there are no flour mills, is to grind the wheat grain between mill stones into meal (flour). In Presidency towns, even the very poor have their wheat ground at the flour mills which are established and worked by electric motors or small oil engines. In the City of Bombay such mills are dotted all over the place. The home-(hand) ground flour is classified into three portions :—(1) *Sooji* is the coarse flour derived from the outer coat of wheat; (2) *Atta* is the finer flour from the middle portion; and (3) *maida* is the flour of the innermost layer. *Atta* is used for making *Chappatis* or *rotis*, unleavened bread. Flour is kneaded with water into dough, which is spread over on a smooth surface to the required thickness, and baked over a fire or on a hot earthern platter. *Chappatis* are generally eaten with other vegetable foods or with milk or ghee. They are always eaten freshly prepared, as stale *chappatis* are dry and hard and consequently difficult of digestion. *Chappatis* prepared with ghee are more agreeable to the taste and keep longer. They form a part of every day meal among all well-to-do Indians.

Sooji and *maida* are used in the preparation of Indian confectionery. "*Halva,*" so extensively sold in Indian

bazaars, is prepared by boiling *sooji* well mixed with ghee, sugar and water to the required consistence. It is a dear and heavy food.

Wheat or its flour may be rendered unwholesome by being kept in a damp place or being attacked by certain fungi, the most common being Puccinia graminis which produces the "smut" of the wheat. Vibrions may be present in damp fermenting flour. Acari farinæ are also common in damp or inferior flour which is beginning to change.

Bread is also largely eaten in India. It is prepared in the same manner as in Europe, by addition of yeast to the dough or by addition of baking powders (alkaline carbonates with an admixture of tartaric acid), or by charging the dough with CO_2. Ordinary white bread is made from flour; brown bread is made from whole meal, and "whole meal" bread is made by addition of finely ground bran. This last variety is much used by persons suffering from chronic constipation because of its laxative properties.

Biscuits are prepared from flour either plain with water or with addition of butter and sugar. They are baked until all the water is driven off and without the use of yeast or any other means of raising the flour. Biscuits contain a large amount of nutrient material, and are also easy of digestion, and being dry keep a considerable time.

Rice constitutes the main food of the people of tropical countries. Rice is the produce of a grass plant "Oryza Sativa," sub-order Oryzæ of the Graminacæ. It is extensively grown all over India and Burma; in some places as many as four crops are obtained annually. According to Prof. Church: "The analyses of a large number of samples of "cleaned" rice give figures which are wonderfully accordant, considering the difference in appearance of the specimens

and the very diverse conditions under which they are grown." The following is the composition of rice :—

Water	.. .. ..	12.8 per cent.
Albuminoids	.. ..	7.3 ,,
Starch	.. .. ..	78.3 ,,
Oil ..	.. .. ..	.6 ,,
Fibre	.. .. ..	.4 ,,
Ash	.. .. ..	.6 ,,

The nutrient ratio is 1: 10.8 and the nutrient value is 86.5.

The mineral matter consists of the phosphates of potash.

Rice is the staple food of the natives of India. It is obtained from *dhan* or paddy or unhusked rice by pounding. In many districts *dhan* is boiled and dried by being exposed to the air and then unhusked by pounding. Hulled or husked rice is called *chaul*. *Chaul* boiled and cooked is called *bhat*. In this process only so much water should be taken as can be absorbed by it; if boiled in a large quantity of water, the mineral salts are dissolved out and lost as the excess of water is thrown away. Rice parched is known as *kurmurah* and is used by labourers at midday meals and by travellers. In Indian dietaries, rice is prepared in many ways with milk, sugar, mollasses, cocoanut juice, etc.

Newly gathered rice is said to be unwholesome, as it is not easily digestible. It produces disorders of the alimentary canal, such as diarrhœa. Rice is deficient in mineral salts and also nitrogenous matter; long continued use of this food alone deteriorates health, as the nutrient ratio is insufficient being 1 to 10 of albumin, while the standard ratio of perfect food is 1 to 5, a ratio which is present in wheat.

Maize or Indian corn is largely grown in India, and is commonly called *macchai* in the North and as *butta* in the Bombay Presidency. The original home of maize or Zea Mays is South America. The seeds are large and yellow.

Maize is rich in fatty oils amounting to as much as 5 to 8 per cent., proteins 9 to 12, carbo-hydrates 65, salts 1 to 2 and water 14. It is, therefore, very nutritious; but because of the large quantities of fat, it is liable to become rancid and mouldy, and because of the deficiency in gluten it is not adapted for making bread. It has also a peculiar "harsh" flavour. Although not a very popular food, it is largely consumed by the peasant. The dry seed is ground into flour and prepared into a porridge or with milk into a pudding, or the whole seed is parched in hot sand and sold as "pop-corn." "Corn flour," extensively sold in Indian bazaars, consists of maize flour deprived of its "harsh" flavour by treatment with a weak solution of caustic soda; in this process it loses a considerable portion of proteids and fats, leaving only pure starch.

Barley is the grain of Hordeum Distichon. It is grown largely in cold climates and also in tropical countries. In commerce it is found with husk and when ground with it forms *barley meal.* This is largely used as horse-food. When deprived of the husk, it is called *pot-barley* and, when further rounded, it is called *pearl-barley.* Fresh barley ground into flour is called *patent* barley. *Malt* is the product of barley, yielded when it is allowed to germinate and germination stopped at a certain point by dry heat. Barley is not much eaten as food, but used in the preparation of malt and in the manufacture of beers and spirits. Barley flour is inferior to wheat flour as it contains very little gluten, and is therefore unsuitable for making bread. Pearl barley is used for making "barley water," a pleasant and demulcent drink for the sick.

Oats are the product of Avena Sativa. In commerce it occurs in husk, but when unhusked it forms *groats,* the flour of which is *oatmeal.* In Scotland and the north of England it is largely used as food: (1) *oat-gruel,* (2) *porridge* and (3) *brose.* Gruel is made by boiling the groats with water or milk, and porridge by stirring the meal in boiling water until it comes to the consistency of pudding. Brose is prepared by

treating the oatmeal in meat or cabbage soup. Oats are largely used as horse-food. It is a highly nutritious food, as it is very rich in fat (10 per cent.) and nitrogenous matter (16 per cent.), and that it is so, is proved by the exceptionally good physical condition of the Highlanders. Others, however, do not appear to flourish on it, as porridge is apt to have an irritating effect on the intestines, causing diarrhœa. The nitrogenous matter is chiefly legumin with little or no gluten.

Rye (Secale Cereale) is largely cultivated in the colder climates, especially in Russia and Germany. Rye-seed is not unlike wheat, but is darker and smaller. Rye is subject to a peculiar fungus disease due to a mycelium of Secale Cornutum, which grows at the expense and in place of the grain, producing what is known as *ergot of rye*, and which attains to about 3 times the size of the normal grain. It is black in colour and gives off a sickly odour and is of nauseous taste. If ergot-rye is allowed to germinate, it produces on its surface several club-shaped growths termed Claviceps Purpurea, which contain the spores; when these ripen they are liberated into the air, and find attachment to the pistol of a flower of rye and impregnate it, and thus the ergots of rye are developed. Pure rye is very nutritious, as the percentage of proteins is about 10 and of fat 2. The proteins consist largely of gluten; hence rye flour can be made into bread; the bread is however dark, unpleasant to the taste and indigestible.

Ergots, because of their size, are easily sifted from the normal grain and collected and sold. Their active principle 'ergotine' and the extract and tincture are valuable drugs; their therapeutic action is well-known.

Millets are other cereals largely grown in India and consumed as food. They are the (1) great millet or *joar*, the products of Sorghum Vulgare, (2) *bajra* or bulrush millet, the produce of Pennisetum Typhoideum, (3) *raji natchni* of Eleusine Coracana and (4) *chena* or Indian millet of Panicum Meliaceum. As a rule, millets are the produce of an

autumnal harvest. All these millets are smaller in size than the cereals (wheat, etc.) previously described, with the exception of Panicum Meliaceum or Indian millet, which has a high nutrient ratio (1 : 6) ; all the rest have very deficient ratios not unlike rice. These minor cereals form the staple diet of the hill tribes, and are also consumed by Indian peasantry during time of scarcity and famine. They are eaten as gruel (*conjee*) or made into cakes or scones.

Pulses are the seeds of leguminous plants. As compared with the cereals, they are richer in albuminous matter, vegetable fats and mineral salts. Pulses contain twice as much protein as wheat and four times as much as polished rice. Their proteins are of a higher biological value than those of cereals, but not as suitable as those of animal food. An ounce of Dhal contains as much protein as one ounce of meat, twice as much as an ounce of egg, and seven times an ounce of milk.

Some pulses and beans contain as much as 18 per cent. or even more of vegetable fat and about 4 per cent. of mineral salts. The nitrogenous matter they contain varies from 17 per cent. to as much as 35 per cent. and consists of legumin or vegetable casein. The legumin is generally combined with sulphur and phosphorus, which naturally add to its nutritive value, but render it somewhat difficult of digestion and apt to produce flatus. The starch is comparatively less than in cereals, averaging about 56 per cent. In India these pulses are generally eaten with rice and form the staple diet of Hindus. The pulses are first denuded of their seed coats or skins, and prepared in various ways either parched and ground into meal and prepared into curries or split and boiled with condiments, or ground into flour and made into confectionery.

A few of the important pulses used as food in India are briefly described below.

(1) The groundnut or peanut; the seed of Arachis Hypogaea, sub-order Papilionaceae. The seeds grow in pods partially buried in the ground hence called groundnuts. Each pod is about 1 to 1½ inches long and may

contain 2 or 3 seeds. Its nutrient ratio is 1 : 5·4 and it contains 25 per cent. of albuminoids and as much as 50 per cent. of vegetable oil. The nutrient value is 151. Oil pressed from the seed is *bhoiseng* oil. It is used for culinary purposes instead of ghee and is used also as an adulterant of ghee. The split seeds are fried and mixed with molasses or *ghur* or jaggery, pressed into small squares and eaten. The cake, after the oil is expressed is used as cattle food.

(2) Gram or chick-pea, the seed of Cicer Arietinum, sub-order Papilionaceæ. Common gram is cultivated almost all over India, but chiefly in the North. The seed is collected and dried in the sun. The unhusked seed is used as horse and cattle food. Gram parched and unhusked is largely consumed by the labouring classes. The nutrient ratio is 1 : 3·3. The percentage of albuminoids is about 19, starch 53 and oil 4·5. The nutrient value is 84.

(3) *Kesari* or *Teora* or *Tuwar Dhal* is a vetch, the seed of Lathyrus Sativa, sub-order Papilionaceæ. *Kesari Dhal* is consumed by all classes but especially by the agricultural classes. The nutrient ratio of the *dhal* is 1 : 1·75. It contains albuminoids 32 and starch 54 per cent, and a very small percentage of vegetable oil. The nutrient value is 87. Occasionally a bitter poisonous principle is present rendering it unwholesome and is said to be the cause of the disease known as Lathyrism. The *dhal* is boiled with spices and condiments and prepared into a thickish paste or curry and is consumed with *chappaties* or rice.

(4) The garden pea of Pisum Sativum and (5) the lentil of Lens Esculenta (Indian *Mussoor*) may be treated together. The pea is consumed as food when it is green—not ripened, and the lentil, which is regarded as a pulse of inferior quality, is eaten after the husk is removed. The lentils contain a bitter principle which is removed by soaking them in cold water, to which some soda carbonate is added. The nutrient ratio of each is about 1 to 2·5 and albuminoids 25 per cent. starch about 58 per cent. and oil 1·5. The nutrient value is about 85.

(6) The soy or soja bean is the seed of Glycine Soja, sub-order Papilionaceæ. This bean is largely consumed in China and Japan; of all the pulses or beans, the composition of soja bean is the richest in albuminoids and vegetable oils, the percentage being 35 and 19 respectively. The nutrient ratio is 1 : 2. It is rich also in mineral salts, chiefly phosphates and potash. The nutrient value is 105.

(7) *Mung* bean is the seed of Phaseolus Mungo. There are three varieties: P. Manx producing the black, P. Aureus the yellow, P. Mungo the green. The pods of these plants are about 2 inches in length, containing about a dozen seeds. The nutrient ratio is 1 : 2·5, albuminoids 22 per cent. and fats 2 per cent; the nutrient value is 83. This bean is largely indulged in by the affluent classes and has the reputation among Indians of being easily digestible, and is therefore eaten during illness and convalescence. It is taken in the shape of *Mung khichri*, a dish prepared by boiling *mung*, rice, ghee and condiments in water to a certain consistency.

(8) The lab-lab bean; this lentil is the produce of Dolichos Lab-lab sub-order Phaseolae. The plant is a native of India and cultivated all over the land; the pod is about 2 inches long and contains about 4 seeds. Both the green pods and the ripe seeds are largely used by all vegetarians. The nutrient ratio is 1 : 2·5. They contain a large percentage of albuminoids (20 per cent.) and of fat 2 per cent. The nutrient value is 80. There are many varieties of this plant, and the beans may be large or small according to the size of the pod. Of the numerous forms of lab-lab, almost all are eaten as green vegetables.

Cereals and pulses are collected in crops. They should, therefore, be carefully sifted, and stored in clean bags in properly paved and dry godowns or granaries. If not properly attended to, they are liable to be rendered unwholesome by damp. They may become mouldy, and ferment and decompose. Grain in this condition is positively dangerous, and, if consumed, produces symptoms of severe gastro-intestinal irritation, causing violent vomiting and purging and even death. All such grain, therefore, should be condemned. Large consignments of damaged, mouldy, wet and fermenting Rangoon rice have been, on several occasions, seized by the Health Department of Bombay under Section 415 of the City of Bombay Municipal Act. The object was to prevent its entrance and sale in local bazaars, so that the same may not be used for human consumption.

Certain cereals are affected by specific fungi. Rye is ergotised by the mycelium of the fungus (Claviceps Purpuræ) Secale Cornutum. The ergots if not carefully sifted and removed, but ground into flour with rye and made into bread and eaten, give rise to a disease called "Ergotism." The initial symptoms generally are vomiting and diarrhœa, followed by either gangrene of the extremities or convulsive fits.

Wheat is liable to be attacked by a parasitic fungus, the Ustilago Carbo, producing "caries" or "smut" of the wheat. When wheat is ground into flour with smut, it gives a disagreeable odour and the bread turns bluish in colour; if eaten, it causes diarrhœa. The presence of acarus farina

indicates that the flour is about to change, and if vibrions are discovered the flour is fermenting and therefore unwholesome.

Occasionally wheat flour is adulterated by an admixture of rye flour and, as rye grain is often ergotised, the use of such flour in bread may cause symptoms of Ergotism. Wheat flour may also be adulterated by the addition of the flour of darnel seeds or Lolium Temulentum and of the flour of purple cow-wheat or Melampyrum Arvense. The latter gives bread a bluish-violet tint but causes no poisonous or injurious symptoms. The addition of the flour of darnel seeds does not impart any colour to the bread but is decidedly poisonous, producing vertigo, hallucinations, delirium and other narcotic symptoms. The Lolium flour is readily detected by the addition of alcohol, which gives it a greenish hue with a bitterish repulsive taste and, on evaporation, leaves a resinoid extract of a very unpleasant taste; with pure wheat flour, alcohol gives a straw-coloured solution with agreeable taste. Two alkaloids have been isolated from the darnel seeds: loliine and temuline produced by a parasitic fungus. Loliine is a digestive irritant, while temuline is toxic—a nerve poison.

PARASITES.

There are certain parasites which affect grain, flour, peas, etc.; these parasites may be divided into two classes, animal and vegetable.

I. ANIMAL PARASITES.

The *Calandra Granaria*, or the corn weevil, is much larger than the flour mite. The insect perforates the shell and abstracts the contents leaving only the outer shell. It attacks the grain while standing. It is chestnut-brown in colour, and unlike the rice weevil has no power of flight, the elytra being firmly cemented together.

The *Acarus Farinæ* is found in flour which is beginning to change. It can be distinguished from the Acarus Scabei

which it somewhat resembles, by the fact that its legs are thick right up to the end, while those of the Acarus Scabei taper to a thin end.

The *Bruchus Pisi* attacks peas. It is closely allied to the Br. Rufimanus which attacks beans. It is the larval forms of these insects which cause the damage. The grubs live in the seeds, and as a result the latter may not germinate, or if they do, the resulting plants are weakly. The adult Br. Pisi is oval, and dark in colour. The four basal joints at the antennæ are red, as are also the shanks and tarsi of the two front pairs of legs. The adult beetles lay their eggs on the pea-pods when they are very young. The larva or grub, on hatching, bores into the pea and finding nourishment develops to its full growth. It then pupates in the pea, having first eaten its way to the outer coat, so that, when the beetle is mature, it has only to break through the thin outer skin.

The *Bruchus Rufimanus*, or bean weevil, lays its eggs on the very young pods in the fields. The grub bores its way into the bean and there develops. Two, three or more may be found in the same bean. The full-grown grub pupates in the bean and then, in the spring or earlier, the adult beetle emerges. A round hole shows the place of emergence. In beans still containing the beetle, a little round patch on the outer skin marks the place where the beetle lies.

The *Calandra Oryzae* or rice weevil is dark, reddish-brown in colour, with four dull reddish spots on the elytra. Its length is about 4 m.m. It attacks all kinds of stored grain, *e.g.*, maize, rice, buckwheat, and it also attacks peas and beans. The female pierces a hole and then lays an egg. There are upwards of four broods in a year. The larvæ hatched from the eggs, consume the contents of the grain and then enter into the pupa stage for a few days and finally develop into the insect which leaves the grain. The metamorphosis occupies about one month to six weeks. This weevil is a most destructive insect.

Tylenchus Tritici.—Grain becomes infected by a worm which is really the larval form of a nematode. It is usually seen in grain kept in damp places. The worm causes the grain to become small, short, thick and blackish, and on examination one finds a thick shell filled with a blackish substance.

PREVENTIVE AND REMEDIAL MEASURES AGAINST INSECT PESTS IN GRAIN.

(1) The godowns used must be free from these pests before the grain is introduced and all doors and windows should, as far as possible, be made insect-proof. If the godown is already infected, it should be thoroughly fumigated with sulphur dioxide by means of a Clayton apparatus.

(2) No infected grain should be knowingly admitted into a store.

(3) If infected, the grain should be fumigated before introduction. This can be done by using the Clayton apparatus or by using an air-tight bin of known dimensions. Place carbon bisulphide in a shallow dish and lay the whole on the surface of the grain in the bin and close the lid and leave for 24 to 36 hours. The quantity necessary is about 1 to $1\frac{1}{2}$ lbs. for every 1,000 cubic feet capacity of the bin. It must be remembered that carbon bisulphide is inflammable.

(4) The gunny bags in which the grain is packed should, from time to time, be fumigated to free them from any insects that may exist in them.

II. VEGETABLE PARASITES.

(1) *Puccinia Graminis* is a fungus which attacks many varieties of grain causing a condition known as rust. A spore becomes attached to the grain and sends small filaments into the interior. These increase and form a dense network and later, small cellules develop which enlarge and become coloured. These cause the cuticle to distend and finally rupture. The fine powder which then appears on the surface gives rise to the name of rust.

Ustilago Segetum or *Smut* is a common parasite of corn. It attacks all cereals and is characterised by the grains being filled and destroyed by black dusty spores which, unlike Bunt, are quite conspicuous in the undisturbed plant. Further, it is more common in barley and oats. The spores of smut are smaller than those of Bunt, and their surface is smooth. In the case both of smut and Bunt, infection takes place when the plant is quite young, the fungus pushing up inside the plant as it grows, until ultimately the immature seeds are attacked. Among standing corn which is infected, withered heads can be seen, from which, if rubbed or even touched, a fine powder consisting of the spores of the parasite falls off.

The smut fungus in its resting stage is usually sown with the seed and both germinate at the same time. The mycelium of the fungus spreads throughout the tissues of the host but does not produce any malformation until the head begins to form. The best method of prevention is to sterilise the seed before sowing by soaking it in a solution of copper sulphate (one pound in 20 gallons of water) for 12 to 16 hours and then placing in a solution of milk of lime (14 pounds of quicklime in 20 gallons of water) for five minutes. Then dry and sow.

Telletia Caries or *Uredo Fœtida* or *Bunt* chiefly attacks wheat and is characterised by the grains being filled by a black mass of spores. The external appearance is not altered, or, if at all, only to the extent of a slight darkening. If the affected grain be cut or crushed, a black powder is seen which, when rubbed has a greasy feel and emits a fœtid smell. Ears that are attacked are lighter than sound ones and therefore stand more erect than the sound ones, and they also remain green longer as the harvest approaches. Frequently, so long as the ears remain undisturbed, the black spore masses remain unseen.

Penicillium Glaucum is a common mould of the air. It consists of long threads interlaced to produce a net work

The threads branch and some produce spores. This mould produces a greenish growth on damp flour bread and on cheese and damp grain.

Claviceps Purpurea.—Rye is subject to a disease produced by this fungus, the growth of which causes the grain to enlarge and become black on the surface, but in the interior the grain is somewhat cream-coloured. Ergot may be detected in the flour by the microscope, by which the mycelium and spores of the fungus are laid bare, and also by chemical means.

Sporisorium Maidis causes a disease in maize which has been alleged to be the active agent in the causation of the disease in man know as Pellagra, but there is reason now to seriously doubt the truth of this assertion.

Aspergillus Glaucus and Mucor are species of other moulds to be found in damp grain.

FRUITS.

In India there are many fruit-bearing trees. They yield fruits in seasonal crops, or the fruit may be borne perennially. Fruits are relatively expensive, and therefore are consumed only in comparatively small quantities. They are rarely included in the dietary of the poor man, except the mango and jack fruit when there is a plentiful crop. They are valued rather on account of their pleasant flavour and agreeable taste and other properties than for the nourishment they contain.

Ripe tropical fruits are almost all luscious. When they are over-ripe, they begin to change, ferment and decay; in this condition they are highly unwholesome and injurious to health; large quantities of such fruit, especially mangoes, custard apples and plantains, are destroyed annually by the Health Department of Bombay.

Fruits are not good sources of energy to the body, their calorific value being very low. They are very poor in fat and protein, about 1 per cent. of each and contain 5 to 20

per cent. carbohydrates. Some of them are rich in Vitamins A and C. The value and importance of fresh fruit like fresh green vegetables are due to the organic acids, free and combined with Ca, Na, and K, and the mineral phosphates, carbonates, sulphates and chlorides. Malic Acid is present in apples and pears, oxalates in tomatoes, plums, strawberries, citric acid and citrates in lemons, limes, oranges, and tartaric acid and racemic acid in grapes and raisins. The organic acids increase the appetite and digestion, the phosphoric acid increases the phosphates in the red blood cells, and the potassium salts promote the formation of white blood cells.

Fruit like other foodstuffs is liable to decay. Fungi grow on them, producing sugar and peptones, yeast ferments the sugars, and so also various other bacteria cause the fruit to putrefy. Fruit can be preserved by cold storage, chemicals, evaporation, drying, sterilisation or conversion into preserves or jam.

Fruits can be preserved for a long time by keeping them at a temperature of 34° F. which prevents the development of the spores of Fungi or the growth of bacterial organisms.

Fruits can also be preserved by placing them in a solution of borax and boracic acid, salicylic acid or formalin.

The term evaporated apples, is applied to apples dried artificially instead of being exposed to the sun's heat. Fruit can be dried by sun-drying, baking, or by the hot air, cold-air, and vacuum process.

Much fruit is also preserved by sterilisation and sold bottled or canned.

Fruit can also be preserved by boiling with sugar until the combination has sufficient consistency to set on cooling, to form jellies and jams. The sugar has antiseptic properties and the boiling ensures the death of pathogenic bacteria. Amongst the changes which occur are the destruction of bacteria, yeast, moulds, and their spores, the saturation of the fruit with

sugar, the transformation of the sucrose into invert sugar (dextrose and lævulose) by the free acids of the fruit and the conversion of the pectose bodies of the fruit into pectin or vegetable jelly which causes the jam to set when cooled. A deficiency of pectose bodies has led manufacturers to use other substances to gelatinise jam. The addition of such substances *e.g.*, apple stock, is considered as an adulteration. Jams and jellies are artificially coloured by various substances.

The juices of ripe fruit when properly expressed and prepared are sold as fruit juices and fruit syrup, the latter containing sugar amounting to 50 per cent. They form good non-intoxicating beverages containing the free and combined organic acids and the fruit sugar and possess natural flavour.

NUTS.

Nuts *e.g.*, walnut, cocoanut, almonds, pistachios are largely used in India. They are very nutritive on account of the large amount of fat and protein but not so digestible on account of the cellulose. Their general composition is as follows :—

Water	4 to 5 per cent.
Protein	15 to 20 ,,
Fat	50 to 60 ,,
Carbohydrate	9 to 12 ,,
Cellulose	3 to 5 ,,
Mineral Matter	1 per cent.

They are rich in Vitamin B but have very little Vitamin A and Vitamin C is absent.

ROOTS AND TUBERS.

Roots and tubers *e.g.*, Potatoes, Beet-root, Turnips, Parsnips are store houses of carbohydrates and therefore, contain energy yielding reserve material. They cannot, however, solely maintain health. Fat is practically absent and the amount of protein is very small. They cannot be replaced by cereals in a diet and their value depends on the

presence of mineral salts specially of Potash. They also contain Vitamins A, B and C.

Potatoes for instance contain 13·5 to 29 per cent. carbohydrates, (starch being 13 to 25 per cent., sugar ·56 to 3·3 per cent.), fat ·1 to ·75 per cent. nitrogenous matter ·4 to 2·8 per cent. and salts 1 per cent. Fresh tubers, vegetables and fruit are preferable to dry ones. Cooking deprives tubers of a considerable portion of their nutritive properties as the Vitamin C is destroyed and the mineral salts pass into the water. Potatoes should, therefore, be boiled with their skins on.

GREEN VEGETABLES.

The leaves of green plants consist of a framework of fibro-cellulose upon which the protoplasmic cells are spread. Their value cannot be estimated in terms of protein, fat and carbohydrate. They contain 5 to 15 per cent. of solids, the remainder being water. The amount of protein is 1 per cent., fat ·1 to 2·5 per cent., carbohydrates 2 to 10 per cent., and fibro-cellulose ·5 to 2·5 per cent.

They are defective, therefore, as a source of nutriment to man. Fresh green leaves, however, are absolutely essential for our well-being. This may be due to the Vitamins A, B, C present. Moreover they contain important salts malates, oxalates, tartrates, citrates, phosphates and sulphates of calcium, sodium, and potassium, besides the free organic acids, which are necessary for the blood and secretions. In the treatment of disease, *e.g.*, Scurvy, constipation, gout, etc. fresh vegetables play an important role. The cellulose forms an indigestible residue in the intestines and stimulates the intestinal action by acting as a ballast. They are therefore useful in constipation. It is essential therefore that fresh vegetables *e.g.*, cauliflower, cabbage, lettuce, etc. should be eaten daily.

In India, green vegetables are consumed largely. Some green vegetables are eaten raw, unboiled. The chief of these

are salads, water cresses, spring onions, celery, lettuce, small white radishes, red table radishes, tomatoes, cucumbers, etc. Green vegetables *must, before eating,* be carefully selected and washed. This is very essential, as most vegetables are raised by the *malee,* or vegetable farmer, on soils which may have been contaminated with sewage or on soil recently reclaimed by city refuse, or they may have been raised on land by the side of drains, or again, may have been watered by drain water, or water otherwise contaminated with fæcal or other matters. Therefore, they may have been contaminated with pathogenic bacteria and, if not properly washed, cleaned and dressed, are known to have caused cases of Cholera, Enteric Fever and Dysentery. Special attention should be paid to the roots and the outer foliage, as these may be impregnated with the ova of *ankylostoma, ascaris lumbricoides,* etc.

Green vegetables are eaten also after being boiled with condiments or prepared into dishes with addition of butter etc. The vegetables most commonly eaten thus in this country are cabbage, cauliflower, spinach, lady's fingers, brinjals, white and red gourd, and a variety of *bhajees* prepared from the young shoots and young stems and leaves of various edible plants.

CONDIMENTS, SPICES, ETC.

Indian dishes are generally prepared with condiments and spices. The chief object is to season the food and make it more appetising and to induce a greater flow of digestive juices by exciting a turgescence of the blood vessels of the stomach. They have no direct nutritive functions. The spices are all vegetable products derived from various species of tropical plants. They may consist of the fruit, bark, stem, roots and flowers and are conserved in the dry state. They contain volatile or essential oils and aromatic resinous matters. The oils consist of ethers, aldehydes or terpene hydro-carbons, which give the spices their

aroma and pungency. The distinction made between spices and condiments is purely conventional; the following spices are generally used in this country: cloves, cinnamon, coriander, saffron, nutmeg, mace, chillies, ginger, pepper, mustard, turmeric, dill, cardamom, cummin (*zira*) and fenugreek (*meti*).

TEA, COFFEE AND COCOA.

Tea consists of the young shoots and leaves of Thea Chinensis and various hybrid species of the genus Camellia. The leaf has a characteristic appearance.

Teas vary in quality according to the country and the age of the leaves when picked. They are named according to their position, the size of the leaf increasing from the tip down to the stem, *e.g.*, Flowery Orange Pekoe (derived from the tip-leaf), Orange Pekoe (next leaf to the tip), Pekoe, Souchang, Congo and Bohea, the two latter being the largest leaf next to the stem. The China teas are the most delicately flavoured. The best Indian Teas are from Assam and Darjeeling. Certain scented teas develop their aroma and flavour by being mingled with flowers *e.g.*, Jasmine.

In the preparation of tea the leaves are first withered by being put on wire trays and exposed to the sun, they are then rolled, next moistened and allowed to ferment in the air, and lastly dried or fired to stop fermentation and to harden the leaves. There are two varieties of tea—Black and Green—the green being unfermented.

Black Tea contains about 6 per cent. of Tannin, 2·3 per cent. of Thein, besides an aromatic oil, albumin, extractives, dextrin, and mineral salts. Green tea contains more tannin than the black tea.

Tea is very much used in India by the rich and poor, and largely consumed in the Irani and tea-shops, in Bombay. The important constituents of infusion of tea are Thein Volatile oil, and Tannin, but dextrin, gum, resin, pectin

and albuminoids are also present. The Thein and oil are extracted soon, but tannin depends on the time taken for extraction. The character of the infusion will depend on the nature and amount of leaves, the quality of the water, temperature and period of extraction. In the preparation of a cup of tea, water which is just boiling should be poured upon tea leaves in a pot and allowed to stand for five minutes and then the infusion emptied into another vessel. Longer infusion will cause extraction of too much Tannin, bitter principle and colouring matter, and will cause loss of aroma. The water if hard will not extract well and if too soft will remove too much of the bitter principle.

Tea on account of its Thein is a stimulant and restorative, but if taken in large quantities may cause dyspepsia due to tannin, and trembling and insomnia due to the volatile oil and thein. If taken with meals the Tannin may coagulate the proteins and hinder digestion. The presence of milk removes the influence of tannin to a great extent by the union of the tannin with the proteins of milk.

Tea may be adulterated in several ways :—

(1) Addition of extraneous matter to increase weight and bulk *e.g.*, foreign leaves, used tea leaves, and also mineral substances such as metallic iron, sand, dust. Used leaves may be dried, mixed with gum, rolled and sold as genuine tea.

(2) Catechu and other substances rich in Tannin may be added to give an artificial appearance of strength to the tea decoction.

(3) The use of several colouring mixtures or "facings" to impart a bright and shining appearance to an inferior tea. For this purpose soap stone, Gypsum, Prussian Blue, Graphite, Indigo, Turmeric, etc., are used.

The legal standards laid down for tea are :—

Tea dried to a constant weight at 100°C. should yield 4 to 8 per cent. of total ash, the soluble ash being 40 per cent. of the total ash. On boiling in the proportion of 1 part of Tea to 100 parts by weight of distilled water for one hour Tea should yield 30 per cent. or more of extract.

There are special tea-tasters who by making an infusion in a standard manner, can tell from the flavour, aroma, body and strength, the quality of a tea.

Coffee is the roasted seeds of Caffea Arabica and allied species. There are several varieties of which Mocha Coffee is the best.

French Coffee consists of a mixture of coffee with chicory (30 to 70 per cent.), caramel, and sometimes other vegetables. Coffee contains an alkaloid, caffein (about 1 per cent.), an astringent, coffeo-tannic-acid (20 per cent.) an aromatic oil, fat, legumin, dextrin, sugar and mineral salts.

When Coffee-berries are roasted, they swell with the formation of gases, a large amount of moisture, fat and caffein are lost, sugar is transformed to caramel and an aroma and flavour are developed.

In making a cup of coffee just boiling water should be added in the proportion of 2 ounces of the roasted coffee to 1 pint of water.

The most common adulterants of coffee are chicory, caramel and numerous roasted grains such as corn, wheat, rye, and roots and seeds such as dandelion, turnips, beans, peas, etc.

The addition of chicory is most frequent. The active principles of coffee (caffein and aromatic oil, etc.), are absent in chicory. Though demanded by many coffee drinkers the addition of chicory is considered as adulteration unless

its presence is prominently stated on a label. The addition of chicory causes a darker coloured infusion, and serves to sweeten it and impart a slightly bitter flavour. Roasted coffee floats for a considerable time in water whereas roasted chicory rapidly sinks.

Coffee extracts are concentrated infusions made by digesting coffee and chicory with water, evaporating in vacuo and adding caramel. They are *convenient for a rapid* preparation of the beverage. They are deficient in caffein and extractives and lack the aroma of fresh coffee. They contain little coffee and much chicory and caramel.

Coffee is stimulant to the nervous system and removes the strain of fatigue. It increases the frequency of the heart and the action of the skin.

Cocoa is prepared from the roasted seeds of the Theobroma Cacao and is a good food and a beverage, the nutritive value being much more than coffee or tea, on account of the larger amount of fat, protein and sugar. The cocoa nibs contain about 50 per cent. of fat, but in prepared cocoas the amount is reduced by hydraulic pressure or the addition of starch and sugar to make it more palatable.

Prepared cocoa contains about 25 per cent. fat, 15 per cent. protein, 1 tȯ 1.7 per cent. Theobromine (akin to Thein and Caffein) 45 per cent. sugar, starch, tannin and 5 per cent. ash rich in potash. Chocolates consist of cocoa from which *much of the fat is removed and sugar and flavoury substances* added. It may be adulterated with foreign starches, fats and cocoa shell.

FERMENTED LIQUORS.

All fermented drinks contain alcohol produced by the action of the yeast plant (Saccharomyces Cerevisae) on a *solution of grape sugar.*

$$\underset{\text{Sugar}}{C_6 H_{12} O_6} = \underset{\text{Ethyl alcohol}}{2C_2 H_6 O} + \underset{\text{carbonic acid.}}{2CO_2}$$

Proof spirit is a mixture of 57.10 per cent. by volume or 49.28 per cent. by weight of pure absolute alcohol in water with a specific gravity of 0·91976 at 60°F. Solutions weaker and stronger than this are known as "under" proof and "over" proof respectively.

Alcoholic drinks may be grouped under (*a*) spirits *e.g.*, whisky, brandy, rum, gin, liqueurs: (*b*) wines *e.g.*, claret, sherry, port, champagne; (*c*) malt liquors *e.g.*, beer and stout.

Spirits are obtained by the distillation of various fermented saccharine substances.

Whisky is prepared from malted barley (malt whisky) in pot-stills and from cereals (barley, rye, or maize, etc. to which a little malt is added) in patent stills (grain whisky). It contains 48 to 56 per cent. alcohol.

Brandy is a spirit distilled from the fermented juice of grapes and contains about 45 to 55 per cent. of alcohol.

Rum is prepared by the distillation of sugar-cane products and has 50 to 60 per cent. alcohol.

Liquors are spirituous liquids sweetened with sugar and flavoured with essences, ethers, etc., and contain 34 per cent. alcohol.

In India, country spirit or arrak is prepared from the fermentation of rice, sap of cocoanut tree, and Mohwra flowers, and contains 40 per cent. alcohol.

Spirits prepared in pot-stills retain the flavour of the substance from which they are prepared, and also get the flavour of the creosotic bodies derived from the smoke.

They contain a large amount of the secondary products of distillation *viz.* the higher alcohols (amyl, butyl, propyl, known as fusel oil, furfural, etc., all of which have a deleterious effect on the body. Whisky and other spirits, therefore, when newly prepared are harsh and unpalatable and have to be mellowed by maturing in wooden casks for seven

or eight years whereby the furfural is oxidised to harmless substances and the higher alcohols are transformed into aldehydes, ether and acids which impart a pleasant flavour and aroma to the spirit and act as a corrective to the action of alcohol.

Grain spirit, also known as neutral or silent spirit is produced in the patent-still which does not allow any secondary products *e.g.*, fusel oil, furfural, etc. and hence does not require maturing. It has no flavour and is added to pot-still spirit to soften its harshness.

Imitations of brandy, whisky, gin, etc. are made by adding caramel or other colouring matter, essences, ethers etc. to silent or grain spirit to imitate the flavour.

Wines—The composition of wines differs, the amount of alcohol in natural wines varying from 8 to 18 per cent. and in fortified wines up to 25 per cent. They also contain sugars, higher alcohols, aldehydes, ethers, free organic acids, and their acid salts, albumins and colouring matter and mineral salts.

Besides producing the effects of alcohol, wines act as food as they contain sugar, mineral salts, vegetable acids and salts, and compound aromatic ethers which increase the digestive juices, and bitters which improve the appetite.

The common adulterants of wine are sugar, saccharose, log-wood and other colouring matters, various ethers, alum, and sulphate of lime. Sulphurous acid may find its way from the inside of casks, or may be added together with sulphites to check fermentation. Alcoholic wines according to the rules framed under the Bombay Prevention of Adulteration Act 1925 must not contain more than 450 parts of SO_2 per million.

Malt Liquors—This group includes beer or ale, and stout or porter. They are prepared by the fermentation of an infusion of malt and hops. Other grain *e.g.*, wheat, rye,

oats, etc., or substances which contain or are capable of being transformed into sugar (*e.g.*, potatoes, beet-root, etc.) can be used.

Beer has been produced from invert sugar obtained by the action of sulphuric acid on rice and other starches. As sulphuric acid may contain arsenic, the latter may be found in such beers sometimes to the extent of 1 gram per gallon which is harmful.

The percentage of alcohol varies from 3 to 7 per cent. There are also contained in beer, free organic acids (fixed and volatile), dextrin, sugar, higher alcohols, malt extract, nitrogenous matter and mineral salts. Stout and porter have the same characteristics as beer with the additional flavour of caramelised materials.

Toddy is the fermented juice from the spadix of the date, palm or cocoanut trees. It resembles beer and contains about 5 per cent. alcohol. It is largely used by the poorer classes as a cheap intoxicating drink.

The physiological action of alcohol on the system is described below, but it must be remembered that the effects of pot-still whisky, brandy, etc., are slightly different from those of pure alcohol, as in addition they invigorate the nerves, enliven the mind, and produce other effects due to the presence of the matured secondary products, *e.g.*, ethers, aldehydes and acids.

Alcohol is a food in the sense that like fats and carbohydrates it is oxidised in the body and furnishes heat and energy to the extent of 7 calories per gram. If taken in strictly moderate doses it does no harm but on the other hand aids digestion and assimilation and stimulates an exhausted heart. But it is not a necessary article of diet for those in perfect health, although in small doses it is beneficial, specially in old age, overwork and fatigue. It is not a tissue builder and cannot be put on a level with

other foods, as when taken continually in large doses, its secondary effects on the muscular and nervous system, its destructive action on the tissues and the habit and craving it creates, outweigh its advantages of replacing a certain amount of fat and carbohydrates, and improving digestion.

Alcohol requires no digestion as it is absorbed from the stomach and finds its way into circulation in fifteen minutes. In small doses it stimulates the appetite, increases the digestive juices (directly by irritating the nerves of the mucus membranes and indirectly after it is absorbed into the blood), promotes the activity of the stomach peristalsis and is, therefore, favourable to digestion. It also reflexly stimulates heart, dilates the blood vessels of the body and increases the functional activity of the organs. In large doses it interferes with the digestion, irritating the stomach causing excessive secretion of mucus, nausea and vomiting. There is depression of the vascular system and fall in blood pressure. Owing to the dilatation of the blood vessels of the skin, there is excessive loss of heat through radiation and conduction leading to a fall of the body temperature. Alcohol does not give warmth therefore when it is very cold, but it lets out the body heat and makes one feel colder. It should be avoided, therefore, before going out in cold or rain, but is useful after coming indoors.

On the nervous system it produces stimulation for a short period due to the increase of the blood flow, followed by a depression proceeding from the highest centres of the brain in a descending scale to the lowest. Hence the earliest signs are loss of control of intellectual, emotional, and muscular powers. There is at first a feeling of well-being, increased physical power and mental ability, the imagination becoming brighter, the intellect clearer, the senses sharper, and sexual appetite is increased. This is followed by depression, the judgment failing first and then the imagination and the will power. The person laughs, talks, sings or cries without

restraint, or there are outbursts of anger and unreasonableness. If more alcohol is taken the movements become uncertain, speech incoherent, and thick, the walk staggering and a torpid slumber follows. Excessive doses may cause paralysis of the cardiac and respiratory centres, and urine and fæces will be passed involuntarily and the person dies.

The effects of chronic alcoholism are:—

(1) Peripheral Neuritis, Delirium Tremens and other forms of alcoholic insanity.

(2) Degenerative changes in the liver (Cirrhosis), kidneys (chronic nephritis), stomach, lungs and blood vessels. Due to vaso-motor paralysis the face appears bloated and blue.

(3) It lowers the resistance to certain diseases for example Tuberculosis.

(4) Alcoholics suffering from pneumonia or undergoing operations accompanied by shock have less chance of recovery.

(5) Lunacy and general paralysis.

(6) The mortality among the intemperate is four or five times more than amongst the temperate of the same age and class.

(7) As alcohol is a protoplasmic poison it interferes with the metabolism of fats and causes obesity, it gives rise to alteration in the protein metabolism and causes Gout and by delaying the decomposition of carbohydrates it may cause Diabetes.

It must be remembered that alcohol increases the sexual desire and paves the way to venereal diseases.

The children of alcoholics are more liable to idiocy, epilepsy, paralysis and early death.

Alcoholics are also more liable to street accidents, and many a driver (engine, motor, or electric) have been responsible for collisions and wrecks whilst driving in a state of intoxication.

Alcohol has also been the cause of much crime, poverty, misery, and social and economic downfall of families. In an inquiry into the expenditure on drink amongst the labouring classes of Bombay it was estimated that amongst some families the average expenditure on alcohol amounted to at least 8 to 10 per cent. of the income. The development of Bombay's industries seems to have been associated with a rise in alcoholism, and in the report on the inquiry it is stated that "as the evils of intemperance are fostered by a variety of causes such as lack of intellectual and other interests and want of opportunities for open air pursuits and healthy recreations, a remedy for reducing the consumption of drink lies in a liberal provision of clubs and other sources of recreation."

As alcohol in small doses has a beneficial action and in large doses is harmful it would be necessary to know how much of it could be completely oxidised in the body without exerting any injurious influences on the tissues. Experiments have proved that 1½ ozs. of absolute alcohol can be oxidised without any narcotic effects being produced and this amount is equivalent to about 2 ozs. spirits, 5 ozs. wine and 1 pint beer.

Idiosyncrasy plays an important part in the amount of alcohol that can be taken; some people stand it better than others.

Spirits should be taken well-diluted, and a certain amount of alcohol will be less harmful if it is spread evenly over the day than when taken at one time.

NATURAL AND AERATED WATERS.

About 80 ozs. of water are excreted daily from the human body, and this is made good by drinking about 2 to 3 pints of water, and by the water contained in food *e.g.*, tea, coffee, milk and other foods. Water improves the digestion, stimulates the contraction of the stomach and dilutes undue acidity. Internally it is a diluent of the blood, it

promotes metabolism, dissolves and flushes out the waste material and thus prevents or cures gout, rheumatism, kidney and liver diseases.

Besides pure water, natural and artificial mineral waters are taken.

Natural mineral waters issue from the soil and contain a superabundance of inorganic salts, and are all more or less naturally aerated. The nature and amount of the various salts differ in different waters, some being sparkling and effervescent. They improve digestion and stimulate the movements of the stomach. They may be classified thus :—

Alkaline gaseous *e.g.*, Apollinaris, Belthal, etc.

Alkaline (containing very little CO_2) *e.g.*, Bath, Spa, Vichy.

Saline gaseous (containing some Na Cl) *e.g.*, Johannis Seltzer.

Saline *e.g.*, Malvern, Kronthal.

Artificial aerated waters are made by charging water with CO_2 at a high pressure (120 to 140 pounds per square inch) and the ordinary bottle may contain 3 to 4 volumes of CO_2 to 1 volume of water.

The following varieties call for mention :—

(1) Ordinary carbonated water, (erroneously called Soda water), which is purified water impregnated with CO_2.

(2) Aerated water with chemical salts dissolved *e.g.*, Lithia water containing 3 to 5 grains lithia carbonate, Soda water (3 to 5 grains soda bicarb), Potash, Magnesia water, etc.

(3) Aerated distilled water free salts *e.g.*, "Salutaris," etc.

(4) Waters prepared in imitation of natural mineral waters *e.g.*, Seltzer water.

(5) Sweet drinks—Waters sweetened with cane-sugar, some acid (tartaric, acetic, citric, or phosphoric), flavoured with essences and charged with CO_2 *e.g.*, lemonade, gingerade, etc.

Mineral waters give a sharp, pleasant taste, relieve thirst and aid digestion by increasing the gastric juice and stimulating the movements of the stomach. The natural salts may have a diuretic or aperient action. They should be avoided in cyanosis, dilation of the stomach, and when appetite is much depraved. The one danger is that they may contain some lead derived from lead pipes through which the water has passed or from silicates of lead which enters into the composition of the glass bottles in which they are contained. They must be prepared from pure water, for if polluted the mineral water will not be sterilised by the CO_2 and may cause diseases. The natural mineral waters are superior to the artificial as they contain certain natural salts not present in the artificial waters.

As CO_2 is absorbed in the circulation, aerated waters are unsuitable for persons whose respiration is impeded by cardiac and pulmonary diseases.

The sweet drinks are refreshing and have a nutritive value on account of sugar, but are liable to produce acidity due to the fermentation in the stomach.

INSPECTION OF FOOD SUPPLIES.

One of the important duties of a Municipality is to provide for the efficient inspection of the public food supply. This can only be done by means of trained Inspectors, who are well acquainted with the appearance of animals and flesh, both normal and diseased, and who are well-versed in the sophistries practised by the dealer.

The Inspector may be called upon to examine a living animal. An animal intended for human consumption should be well nourished, free in its movements, its coat in good

condition and free from sores and scabs. The eyes should be bright, the mouth and nostrils moist but yet free from discharge. The breathing should be quiet and regular and the breath without odour. The pulse should be regular, and there should be no shivering or indication of pain. When the animal is sick, the coat is rough, the nostrils are dry or covered with foam or discharging profusely, the eyes dull the tongue protruding, respirations laboured, and the animal's movements are sluggish. The weights of animals vary considerably, and in general the Indian animal is lighter than the corresponding English animal.

	Indian.		*English.*	
	lbs.	lbs.	lbs.	lbs.
Ox	350 to	400	600 to	1,200
Cow	200 ,,	300	700 ,,	740
Bullock	150 ,,	225	300 ,,	450
Buffalo	500 ,,	700		
Sheep	20 ,,	35	60 ,,	90

The age of an animal is usually reckoned by the teeth as shown in the following table, but there is considerable variation in the time of appearance of the permanent teeth :—

AGE IN YEARS.

Teeth.	Bovines.	Sheep.
2	$1\frac{1}{2}$ to 2	1
4	$2\frac{1}{2}$,, 3	2
6	$3\frac{1}{2}$,, 4	3
8	$4\frac{1}{2}$,, 5	4

In young animals, the cartilages covering the articular surfaces are blue or rosy; as age advances, however, they become whiter. Up to three years of age, one can cut through the ischio-pubic symphysis, and up to four years through the costal cartilage of the ninth rib. At the age of six this is almost impossible. In young animals the bones are small, soft and porous and have a pinkish colour; in older animals

they become larger, harder and less porous, and of a whiter colour. The beef is light-red in young animals, firm and elastic in consistency, and marbled with fat.

In order to distinguish the sex of an animal the following points may be noted. Owing to greater muscular development, the flesh of the bull has less fat than that of the cow. There is great development of the neck, shoulder and hind quarters. The flesh is coarser in fibre and there is an absence of that marbling seen in cow's flesh. . The flesh is dark-red in colour, the muscles tough and cross-grained and the carcass is generally poor in fat. Situated at the root of the penis, which in dressed meat is usually found on the left hand side of the hind quarter, is a muscle, the erector penis ; this muscle is much more developed in the bull than in the bullock, as is also the case with the penis itself. In the bullock the quarters are less developed, the penis and retractor penis are less prominent, and the erector penis is almost atrophied. The scrotal fat is prominent. The anterior part of the ischio-pubic symphysis is very well developed. If the penis has been removed, a furrow corresponding to its position will be found. The joints of a bull are larger than those of a cow, and the neck is very thick compared with that of a cow, ox or heifer. In the cow the quarters are less rounded, the angles of the haunch are prominent, the anterior part of the ischio-pubic symphysis is ill-developed. The udder is present, or if not, then marks of it are left. The fat at the base of the udder is fairly well developed and the supermammary lymph glands are large. In the heifer the mammary gland is poorly developed and is surrounded by fatty tissue.

How to distinguish flesh of one animal from that of another. —A meat Inspector must be prepared to detect the substitution of the flesh of one animal for that of another. Horse flesh is frequently substituted for beef, and a knowledge of the following points may assist in the detection of the fraud. Horse flesh is much darker and coarser

in fibre, and it is without the small layers of fat seen in the muscles (marbling). It has a disagreeable odour, the fat is oily, yellow and soft due to the large quantity of olein in it. The horse's liver has three lobes and no gall bladder; that of the cow consists of one large lobe plus a small supernumerary one. The kidney of the cow is lobulated on the surface, whereas the horse's is smooth and not lobulated. The two kidneys of the horse differ in shape, however, that on the right being somewhat heart-shaped, whereas the left one is ordinarily reniform in appearance. The heart of the horse has two grooves on the surface, the fat is yellow and oily, and is but little seen on the surface. The heart of the cow has three grooves, and at its base has a bone not seen in the heart of the horse. The horse's tongue is much smoother than that of the cow. It is spatula-shaped, and the circumvallate papillæ at the base are situated centrally whereas in the ox the tongue is comparatively pointed with many papillæ at the tip, causing a sensation of roughness when the hand is passed over it, and the circumvallate papillæ are situated at the edges, and not centrally. The horse has a longer neck, the bones of the cervical region being elongated, so also the bones of the limbs. The epiglottis of the horse is smaller and more pointed. The horse's sternum is carinaform in shape. The horse has 18 pairs of ribs, the ox only 13 pairs. Moreover, the ribs of the former are much narrower. In general, the bones of the horse are much heavier.

Substitution of the flesh of the goat for that of the sheep sometimes occurs. Both animals have 13 pairs of ribs. The flesh of the sheep is paler and finer, the fat is firm, white and evenly distributed over the back and sides, and the flesh is rarely marbled. The flesh of the goat is dark and possesses a peculiar smell, especially if old. In the sheep the external covering of fat is well developed, in the goat it is practically absent. The neck, body and quarter of the goat are longer. The sheep's liver, like that of the ox, consists of one large lobe plus a small supernumerary

one situated on its superior and posterior surface. The normal liver of the goat weighs 8 to 10 ounces. It is divided into two lobes, the larger of which is again divided interiorly by a cleft. The breadth varies from 6 inches to 7 inches and the length from base to apex is 7 inches to 8 inches. The small lobe measures about 2 inches in length by 1½ inches in breadth.

The flesh of the pig is paler than that of either the ox or the goat, and is less firm to the touch. The subcutaneous fat is very white and soft. The pig has 14 pairs of ribs. Its liver has five lobes and the kidney is smooth, elongated and flattened so as to somewhat resemble a broad ribbon.

The flesh of the calf is pale-red in colour and not of a firm consistence, and the fat resembles tallow. Slink veal has a gelatinous watery appearance.

Buffalo meat—The flesh is pale-red in colour, the muscle fibres are coarser and looser than in the ox, and the muscular parts are larger. The fat is pure white. The flesh, when cooked, assumes a darker colour and increases in bulk.

The dog's liver is two-lobed and its kidneys are smooth and oblong.

In examining any carcass, the Inspector must pay attention to the following points :—

(1) The colour and transparency of the meat, the smell, consistency and chemical reaction, and the presence or absence of any moisture ;

(2) the amount, character and distribution of the fats, the appearance of the lymphatic glands, serous membranes, articulations and bones ; and

(3) the presence or absence of any signs of lesions or parasites.

Good meat should have the following characteristics—The carcass should be well set as soon as it is cold ; the flesh firm but not tough. It should be well bled and no part of

it purple or speckled. When pressed with the finger, the flesh should not pit, as pitting would indicate the presence of watery fluid, nor should it crackle, thereby indicating the presence of air. No pus should exist in the intra-muscular tissue. The flesh should be fairly dry after exposure to the air. The meat should have a pleasant odour and be bright-red in colour (except in the case of pork, veal and lamb) and should have an acid reaction. The fat should be free from watery juice and blood stains. An excellent test of meat is to insert a clean, long, thin-bladed knife deep into the flesh: in good meat the resistance is equal, and in putrefying meat variable; on withdrawal, the knife should have no unpleasant smell. There should be no smell of physic about the flesh. In temperate climates, the marrow of the hind legs is solid; about 24 hours after slaughter, it is of a light-red colour: if it is brownish or soft, or has black points in it, then the animal has probably been sick or putrefaction is commencing. The quantity of fat varies very much; in an ox it constitutes about one-third, and in a fat pig about half the total. The fat usually solidifies after death. In horses the fat is yellow and oily, and has an unpleasant taste. In oxen it varies from yellow to pale, straw colour. In beef the fat consists mainly of palmitates, in mutton of stearates, and in pork of oleates.

Public Abbatoirs.—For the prompt detection and condemnation of diseased meat public abbatoirs are necessary. By thus concentrating the slaughter of animals in a large, central and sanitary slaughter house, strict and systematic inspection is feasible. Not only is it important that the health and condition of the animal should be good at the time of slaughter, but the method of killing, butchering, preserving, handling, and transporting the meat, require careful supervision by trained Inspectors. Private abbatoirs are not easy to control on account of their number, distance, and irregular hours of slaughtering. The slaughter house should preferably be outside the town near a Railway Station so as to avoid the driving of the animals through congested streets. The following points are important in the construction and management of an Abbatoir:—

The premises should be well constructed and drained, and not within 100 ft. of any dwelling house. The site should admit of free ventilation by direct communication with the external air on two sides at least of the slaughter house.

The internal surface of the walls and the floor should be constructed of hard, smooth impervious material and kept in good order and washed frequently to prevent the absorption of any blood, liquid refuse, etc., which may be splashed.

There should be no direct communication between the slaughter house and any stable, water-closet, privy or cesspool.

No room or loft should be constructed over the slaughter house.

The slaughter house must be protected from rats, mice, flies and other vermin.

The lairs for cattle should not be within 100 ft. of any dwelling house. They should be properly paved, drained and ventilated and no habitable room should be constructed over them.

A sufficient quantity of pure water must be available for the cleansing of the premises and for the use of every animal brought for slaughter.

Dogs should be prohibited and no animal should be admitted unless it is intended for slaughter.

No animal should be kept longer than is necessary for preparing it for slaughter.

All skins, fat and offal should be removed within 24 hours of the slaughtering of the animal and the feeding of animals on refuse should not be allowed. Receptacles of non-absorbent material for the collection of offals, etc., should be provided and kept clean. All diseased carcasses and meat products should be efficiently destroyed and rendered unfit for consumption.

The butchers should be cleanly dressed, and should wash their hands before starting their work and after the slaughter of each animal specially after handling diseased carcasses. Those who are carriers of diseases should not be allowed. The various implements should be sterilised in boiling water and cleaned before they are re-used.

A cold storage room for meat is necessary, as cooling favours good appearance of meat.

The carts in which the meat is transported to the market should be clean and provided with hooks on the roof for suspending the meat.

For a fuller description of slaughter houses—*vide* page 976.

The Inspector should have a good knowledge of the various glands to be examined and their situation. Normally, all the glands are bluish-grey in colour, of firm consistency and moist on the surface.

The following are some of the more important glands :—

The supra-sternal : are found on each side of the upper surface of the sternum.

The pre-pectoral : are situated at the entrance to the chest beneath the great vessels. One of them is always left just beneath the small muscle, which will be found in front of and attached to the edge of the first rib.

The pre-scapular: are found beneath some muscle and in front of and close to the shoulder joint.

The cervical: lie on each side of the trachea or wind-pipe.

The brachial: are found under the shoulder blade.

The mediastinal: lie between the two lungs.

The bronchial: lie on each side of the trachea just at its point of bifurcation.

The superficial inguinal (known as the supra-mammary in the cow): in male animals are usually found buried in the cod fat; in female animals they are readily seen when the udder has been removed. It may be here noted that these glands are much larger in the cow than in the ox.

The deep inguinal or pre-pubic: is lower down on the brim of the pelvis, 4 or 5 inches removed from the spinal column. It is always embedded in fat. Close to this and under the spinal column is a large collection of glands, the external and internal iliacs and some of the sacral.

The renal: are situated behind the kidney.

The sub-dorsal: are found in the fat just beneath and attached to the spinal column.

The hepatic: are found between the portal vein and the pancreas; in very fat animals they may be completely buried in adipose tissue.

The popliteal: is found deeply buried in the muscles at the back of the strifle or knee-joint.

The pre-crural: is found on the outside of the hind quarter buried in fat and beneath the muscle in front of and above the strifle.

It is of the utmost importance that the meat Inspector should examine the glands, especially if the organs have been disposed off. Occasionally, however, the more easily accessible glands have also been removed, leaving only the deeper seated ones, as their removal would necessitate some degree of mutilation of the carcass, thereby lessening its market value. Three sets of glands, however, are practically always overlooked by the butcher, and they afford valuable information to the Inspector. They are (1) the sub-maxillary, which is found on the inner side of the jaw-bone just about its middle. A small tag of muscle which is almost invariably left in this situation, affords a guide in locating this gland; (2) the pre-auricular which, as its name indicates is situated in front of the auricle; and (3) the post-pharyngeal in the posterior wall of the pharynx. The principal disease for which the Inspector should be on the look-out in glands is Tuberculosis, of which the most usual

indication is the presence of soft yellow nodules or areas in the glands.

In cows, usually, the first organ to be removed is the mammary gland. Both sides of this organ should be of the same size, shape and colour and of the same consistency. The spleen is a solid organ; it should be smooth on the surface and on first being removed, bluish-grey in colour. It varies from 14 to 18 inches in length by 4 inches in width and $\frac{1}{2}$ inch in thickness.

The stomach has four compartments; the first and largest is known as the rumen, the second as the reticulum or honeycomb from its appearance, the third as the manyplus or emasum and the fourth as the obomasum. The external covering of the stomach should be smooth, glistening and bluish-grey in colour. The contents should be examined for any signs of drugs.

The covering of the intestines should be smooth and of uniform grey colour. They lie coiled in a mass of fat—the mesentery. The liver is of a reddish-brown colour and of moderately firm consistence and the borders somewhat sharp. In the thicker portions of the liver, the borders are more rounded. The organ should contain no lighter coloured or yellow area. The diaphragm forms a strong musculo-fibrous partition separating the thorax from the abdomen. In its centre it is fibrous and in the periphery muscular. Both surfaces should be quite smooth and glistening and in no part adherent to any organ. The kidneys are solid organs with a lobulated surface and of a uniform brown colour. They are generally concealed from sight in fat. The surface should be quite smooth and glistening. The lungs are soft, elastic and of uniform consistency. They should be of a uniform pink colour, and perfectly smooth on the surface; there should be no yellowish, whitish areas in the interior. The tongue has already been described. It should be examined for marks of erosions, and the large glands situated at its base examined for signs of Tuberculosis.

SOME SOURCES OF ALTERATION IN THE QUALITY OF THE FLESH.

Initial or essential defects including (*a*) *Age :* Very old or very young animals are not so nutritious as the average adult. An old animal is occasionally very deficient in nutritive value; the fat almost disappears and the muscular tissue is in part replaced by fibrous tissue. The flesh of young animals is deficient in salts and fat. (*b*) *Overwork and exhaustion* :—The meat loses value as a food and is often unpleasant to the taste; no animal should be slaughtered when in a tired or frightened condition. The flesh is liable to rapid decomposition. (*c*) *Unsuitable feeding*: Certain medicines given to an animal may produce symptoms in the consumer, *e.g.*, antimony, arsenic, lead, strychnine and phosphorus. Occasionally the smell of the medicine can be detected, and this should lead the Inspector to institute inquiries as to the nature of the illness which necessitated the administration of medicine. Ether, turpentine, creosote, carbolic acid and Hydrocyanic acid are examples of drugs which may impart an odour to the flesh. If an animal has been poisoned by unsuitable food, *e.g.*, yew leaves, bryony, meadow saffron, or by mineral poisons purposely given, there will usually be some indication to be found in the stomach, more marked in the case of mineral poisons, and certain changes may be found in the liver, *e.g.*, fatty degeneration in the case of arsenic and phosphorus. Animals fed on red cabbage and beet leaves may produce a poisonous milk, which in certain individuals may cause acute Enteritis. (*d*) *Starvation* acts much like old age; the meat wastes considerably in cooking owing to the deficiency of fat. (*e*) The flesh of animals killed by *lightning and apoplexy* rapidly decomposes. The organs and flesh are dark in colour, the meat is full of blood, and badly set, as is the case also in *animals which have been smothered or drowned.* If the flesh is full of blood, the carcass should be condemned. In regard to animals injured by accidents, much depends on

the nature and extent of the injuries. If the accident is such as to result in purely localised bruising, this portion of the meat only need be condemned and the rest passed, provided that the bruising is not too extensive and the animal is slaughtered at once. If, however, the accident results in much bruising and injury to the animal and it is not slaughtered early, the flesh is apt to be dark and ill-bled and should be condemned. The flesh of animals dead from accident is usually dark and the serous membranes stained, owing to the animal not having been bled or only imperfectly so. The flesh of animals slaughtered just before, during or after parturition need not necessarily be condemned, unless there is evidence of extravasations of blood or of pyæmia and of inflammation of the pelvic organs and membranes. (*f*) The *diseases*, both infectious and non-infectious, which either on the whole or in part render meat unfit for human consumption, or which depreciate its quality and therefore its market-value, ordinarily met with include Tuberculosis, Pseudo-Tuberculosis, Actinomycosis, Dyscomycosis, Anthrax, Rinderpest, Pleuro-Pneumonia, Swine Fever, Sheep-pox, Erysipelas, and worms of various kinds, etc., etc.

TUBERCULOSIS.

Tuberculosis is a very wide-spread disease in man and animals. It is very common in cattle and poultry and occurs also in dogs, cats and the larger carnivora. In sheep and goats it is comparatively rare, especially in the former. Comparative statistics show that the disease occurs in cattle 16·25 per cent., swine 2·3 per cent. and sheep ·2 to ·3. The horse is also liable. Birds are specially susceptible, the disease causing great mortality in hens, geese, turkeys and pheasants. Most wild animals are susceptible. The disease also occurs in monkeys in confinement and the nodules have a special tendency to break down into a pus-like fluid.

The disease may be either local or general. Small oval or spherical nodules form, and these may soften and become

caseous or contain pus, while others become fibrous or even calcareous.

Tuberculosis is due to a bacillus discovered by Koch. It belongs to the acid-fast group, which also includes the smegma bacillus. The bacilli are straight or curved, non-motile rods from 2 to 4 m.m. in length. They are very difficult to cultivate in the absence of glycerine. They occur scattered in the tissues, or in little round masses. They are usually single, but may sometimes be found lying end to end forming an obtuse angle: true chains are not found. Their resistance is considerable and they can retain their vitality outside the body for a considerable time. Salting and smoking do not kill them. They resist the gastric juice for 6 hours, and a temperature of 60 C. for 15 minutes and drying and putrefaction for a very long time, even months

In *cattle*, generally the lungs are affected, nodules appear in them and these may be firm, caseous or calcified. In addition, one may find caseous Pneumonia and small Tubercular granulations. Along with these changes in the lungs, there may be nodules on the pleura and peritoneum, some of which may be pedunculated. In other cases, however, the abdominal organs may be primarily affected. The udder becomes diseased in about 3 per cent. of cases, but primary affection of the gland is rare.

In *pigs*, as a rule, the disease is abdominal in origin, the liver, spleen and glands being affected. In other cases a caseous Pneumonia is found and in other instances again the organism produces a chronic affection of the lymphatic glands, known as Pig's Scrofula. Tubercular affections of the muscles are less rare in pigs.

In *the horse*, the abdominal organs are the primary seat of the disease, the spleen being enormously enlarged and crowded with nodules. Occasionally, the primary lesions are pulmonary. The mesenteric glands become enlarged.

The disease may spread to the lungs, causing miliary Tuberculosis. In the *cow*, on the contrary, the disease generally commences in the lung with a local tubercle, later the pleuræ are affected causing "grapes" and, later on, there may be a small amount of miliary tubercle.

Action on the Tissues.—The local lesion is a Tubercular nodule of a central giant cell which has many nuclei, often in a ring towards the periphery, but sometimes in a clump at one end. Round this are spindle-shaped epithelial cells, and round these uninucleated leucocytes. Giant cells are found especially where the caseous change is relatively not active. Caseation, softening, calcification or fibrous changes may occur. The general action is to produce pyrexia, perspiration, wasting and waxy degeneration.

In cattle the organism is very often found in the giant cells, and scattered irregularly through the cellular connective tissue elements of the lesion, if little or no caseation is present.

In the horse and in birds one may see enormous numbers even though the lesion be not very acute.

Paths of Infection.—(1) Air passages; (2) alimentary canal; (3) wounds in the skin; and (4) the genital organs, but this method is very rare. If infection is *via* the alimentary canal, the disease usually commences in the pharynx or small intestine.

To detect Tubercle in Carcasses.—It is necessary to examine most carefully the following portions of the carcass:—(1) The pleura and peritoneum for "grapes," which present the appearance of nodules of varying sizes on the serous membranes. If either the pleura or peritoneum in part or whole is missing, the carcass should be rejected. (2) The various organs, *e.g.*, the liver, spleen and kidneys for the presence of tubercles or small nodules; and if these organs are missing, then examine the glands (this should be done in all cases). (3) The glands to be examined have already been referred to in detail, but special attention should be paid to

the postpharyngeal, because they are often early infected, and to the sub-maxillary and pre-auricular because these are often overlooked by the butcher, who may remove some of the more prominent and more easily accessible glands. If on examining a carcass, it is found that the organs have been disposed off and the glands removed and the pleura stripped from the ribs and the diaphragm removed, it is almost certain that the carcass was tuberculous, and it should be condemned. Stripping of the pleura *per se* cannot always be held to be indicative of an attempt to hide evidence of Tuberculosis, as it may have been removed as the result of staining, owing to oversticking in the course of slaughter. This staining spoils the appearance. The glands should be most carefully examined before passing as fit for food any animal which has had its pleura stripped for such an alleged cause.

The question of the suitability for human consumption of an animal suffering from Tuberculosis is at present almost entirely determined on the lines of the recommendations of the Royal Commission, appointed to report on this question. They advised that the entire carcass should be seized, when—

(1) there was miliary tubercle of both lungs;
(2) tubercular lesions were present in the pleura and peritoneum;
(3) tubercular lesions were present in the muscular system, or in the lymphatic glands lying in or between the muscles;
(4) tubercular lesions were present in any part of an emaciated carcass;

and that the affected organs or parts containing lesions be condemned when the lesion was confined—

(1) to the lungs and thoracic lymphatic glands;
(2) to the liver;
(3) to the pharyngeal lymphatic glands;
(4) and to any combination of the above when collectively small in extent.

In the case of the pig, if Tuberculosis is present in any degree, the carcass should be condemned.

Experimental Inoculation.—If a guinea-pig be inoculated in the leg, in 9 or 10 days the popliteal and superficial inguinal glands on the same side will be enlarged; in 14 days the deep inguinal and lumbar glands also. In 21 days the retro-hepatic and splenic glands are enlarged and the spleen and liver show small nodules. Later on, it is difficult to say which side was inoculated and the difficulty increases the further forward one goes. If the guinea-pig be inoculated in the peritoneal cavity, the first gland to become enlarged is the retro-peritoneal near the junction of the mesentery and the abdominal wall, next the retro-hepatic and then the poststernal.

PSEUDO-TUBERCULOSIS.

As the name implies, this disease is occasionally mistaken for Tuberculosis. It is seen frequently in sheep and affects cattle and swine also. It is due to the presence of certain forms of strongyli; other varieties are seen in rabbits and cats. Sheep are affected with the Strongylus filaria and rufescens; cattle with the Strongylus micrurus, especially young cattle, and swine with the Strongylus paradoxus.

The strongyli cause lesions in the lungs, and are liable to be mistaken for Tuberculosis. It must be remembered that this disease is rare in sheep (·2 to ·3 per cent.). The strongyli are filiform bodies with lobed tails occasionally. They live in the bronchi, and the female travels to the terminal alveoli, and there lays her eggs. These eggs may undergo development and set free larvæ which may cause irritation in various parts of the lung, or the young may cause a localised inflammation. As a result of the irritation caused by the eggs or the larvæ, Bronchitis or diffuse Pneumonia may arise and, in addition, small nodules form and it is these nodules that are liable to be mistaken for true Tuberculosis.

Structure of a Nodule.—In the centre one may see an egg containing an embryo, or a free embryo may be seen, or yet again, only a degenerated mass may exist. There is considerable small-celled infiltration of the alveolar walls and an accumulation of corpuscles in the alveoli involved. At a later stage, fibrous tissues form in the alveolar wall. In the neighbourhood of the worm itself, one may see degeneration simulating a fibrous capsule. Occasionally calcification occurs in the nodule. It is very rare to see a giant cell in these nodules.

Mode of Spread.—All the year round numerous free embryos are found in the mucus in the air passages. In England they are specially numerous in March and September. They escape from the animal with the mucus and live on the moist ground for a very considerable time. They can resist drying for a long period. They are probably taken up in the food. Their life history is not accurately known and it is a matter for conjecture whether from the stomach they bore a way to the lungs, or whether, *via* the œsophagus, they creep to the larynx and thence to the lungs. The disease is not communicable to man.

Appearance of the Lungs.—The lung appears firmer than usual. The surface presents a blotched appearance. Some parts are brown-white, others are pink or pale-pink in colour. Nodules of a yellowish white colour are seen on the surface and also in the substance of the lung; they are of firm consistence and vary in size from a pin's head to an ordinary marble. Only the very bad ones need be seized.

ACTINOMYCOSIS.

Actinomycosis affects man, oxen, horse, sheep, pigs and dogs. It is most common in cattle. It is sometimes seen in sheep and pigs, occasionally in the horse and dog, and more rarely in man, resulting from direct injury from the spikes of barley and not from infected meat.

In man and the pig, the disease is characterised by chronic suppurative processes, which often extend to internal organs producing a chronic Pyæmia. In the ox and horse, it is characterised by abundant formation of granular tissue resulting in tumours, especially on the tongue, in cattle.

The disease is due to a parasite which grows in the form of little round masses about the size of a small pin's head. When suppuration is present, they lie free in the pus and, when suppuration is absent, they lie embedded in the granulating tissue. They may be transparent or jelly-like, opaque, or may appear white, yellow, green or black, according to age.

When examined under a microscope, these small masses are seen to be composed of three elements : (1) comparatively thin filaments, often of great length, between which is a fine granular substance; (2) coccus-like bodies formed by segmentation of the filaments; and (3) club-shaped bodies formed by a hyaline swelling of the sheath at the end of a filament.

In the human being, it produces chronic inflammatory changes usually ending in suppuration, which spreads slowly, and is usually associated with an abundant growth of the organism in the filamentous form. Multiple foci of suppuration are seen at the spreading margin.

In cattle, the disease assumes more of a formative type, resulting in abundant growth of granular tissue, forming tumours more or less nodulated. It is rarely seen to a greater extent than 1 or 2 per 1,000 in England. It affects the tongue, lower jaw, lungs, tonsils, liver and intestines, etc.

The tongue becomes large and very hard, due to a great accumulation of fibrous tissue under the mucous membrane, especially in the back and sides. The jaw becomes enlarged, bulged out and nodulated; when cut across, dense bony tissue is seen with spaces containing soft purulent granulation tissue; occasionally a cavity filled with pus is found, or nodules with a mulberry-like spot in the centre.

There is, as yet, no evidence that man is directly infected with the disease from animals, but nevertheless, any animal infected with Actinomycosis should be condemned as human food. This is the rule in most of the American States and in England.

BOTRYOMYCOSIS OR DYSCOMYCOSIS.

Botryomycosis or Dyscomycosis is a disease very rare in man, common in the horse, less so in cattle. It is a chronic disease resulting in the formation of large masses of fibrous tissue in various parts of the body. These masses enclose small purulent foci and may cause fistulous openings just as in Actinomycosis. On microscopical examination, instead of the typical Actinomycosis in small lobuli, one finds clumps of small cocci in rounded masses of from 50 to 100 m.m. in diameter, each mass being surrounded by a zone of hyaline matter, and containing small yellow granules. Each mass is held together by fibrous tissue. The disease is due to a coccus—the Botryomycosis Equi. Grown on potato, it produces a bright orange colour like the Staphylococcus pyogenes aureus, but differs in causing a smell of fresh strawberries. There is no evidence that the flesh is capable of producing the disease in man, in whom the disease is very rare. Cattle and the pig suffer but rarely. The sheep, goat, dog, rabbit, guinea-pig and mice may suffer possibly. In the horse, the skin, subcutaneous tissue and the fibrous tissue of the spermatic cord may be affected. In the cow, the udder and viscera are occasionally attacked.

ANTHRAX.

Anthrax is a disease which occasionally occurs epidemically among herbivora, especially oxen and sheep. The horse, deer and goat are less susceptible. Rabbits, guinea-pigs and mice are very susceptible, pigs are sometimes attacked. The white rat, adult carnivora, birds and amphibia and Algerian sheep are not susceptible ; the brown rat is. The disease is readily contracted by man. Anthrax is a very common disease in India, Persia and Siberia.

It is due to a large non-motile, spore-bearing bacillus, which has a comparatively low power of resistance, being unable to stand exposure to 60°C for long. If kept dry at ordinary temperature, it dies in a few days. It can grow without oxygen, but it grows much better with it. No spores are formed in the absence of free oxygen, and this fact has great value in the question of the disposal of carcasses of animals dead from this disease. Though the organism itself has but low power of resistance, it is quite the reverse with the spores: if kept dry, they will live for a year or more. They resist boiling for five minutes and require a dry heat of 140°C for several hours to kill them. They will live in sewage, in the soil and in distilled water for several months. Spore-formation does not occur in the body of a dead animal owing to the absence of free oxygen. Both the bacilli and the contained spores die speedily if kept within the intact carcass. This points to the urgent necessity of preventing the effusion of blood when disposing off a carcass.

The disease manifests itself in various forms. The most severe form has a sudden onset; it is seen especially in sheep and cattle, and, from its nature, is called fulminant or apoplectic. The animal has loss of appetite, trembling irregular movements, backwards or to one side, dyspnœa, cyanosis, convulsions, escape of blood by the nose or with the urine and fæces, death occurring in from a few minutes to 4 or 5 hours. Another form is splenic fever or splenic apoplexy. This is especially virulent in oxen and sheep. The animal is excitable and restless, and its temperature rises 3° or 4°. The mucosæ are congested, and in sheep this may show on the finer parts of the skin, *e.g.*, inside the forearm or thigh. There may be tremors, erection of the hairs, dullness, prostration, thirst, grinding of the teeth, colic, passage of mucus and blood per rectum, and discharge of blood from the nose. The blood is very dark and usually has a thick tarry appearance. Death usually supervenes in sheep in 24 hours, and in cattle in from 2 to 5 days, and in horses 1 to 6 days. In more prolonged cases, there is widespread œdema, extensive enlargement of lymphatic glands, and, in those about the neck especially, necrosis and ulceration may occur. This sub-acute form is seen more particularly in horses, which are less susceptible than cattle and sheep.

Post-mortem appearance in the Ox.—The spleen is greatly enlarged, dark red in colour, soft and friable. The liver is enlarged and congested and shows signs of acute cloudy swelling. The kidneys and lungs are also congested. The heart shows cloudy swelling, and the intestines are congested and filled with a bloody fluid. The glands, especially the mediastinal, mesenteric and cervical, are much enlarged and surrounded with œdematous tissue; the lymphatic vessels are also swollen and both the glands and vessels contain bacilli, as also do all the organs, especially the spleen. The flesh is darker than usual and is also often dropsical and bile-stained. Putrefaction of the carcass is often rapid. In the very rapidly fatal cases, the changes in the blood and tissues may be but little marked, and after removal of the enlarged engorged spleen and infiltrated internal organs, the carcass is sometimes placed on the market and may pass unnoticed. In more prolonged cases, the changes mentioned above occur, and there is therefore more liability of detection.

The flesh of an animal suffering from Anthrax, in whatever stage, should invariably be condemned. Great care must be exercised, in disposing off the carcass, to prevent any effusion of blood. The best method of disposal is by cremation of the entire carcass.

Anthrax in the pig is comparatively rare; when it does occur, the body is livid and sodden and darker in colour, and the spleen and other organs are affected much as in the case of the ox.

EMPHYSEMATOUS ANTHRAX.

Synonyms.—Symptomatic Anthrax, black quarter, black leg, or quarter ill.

An acute infectious disease characterised by pyrexia, lameness, and a localised, hot, painful swelling on the shoulder, quarter, leg, neck, trunk or elsewhere, tending to emphysema and gangrene, and, when incised, showing black extravasated blood, clotted or frothy. It is due to a rod-shaped microbe with rounded ends, found singly or united in pairs or very short filaments. These microbes form spores even in the body of the affected animal. They are motile and anærobic.

Post-mortem appearance.—The carcass is liable to be bloated with gas and a reddish, frothy fluid often escapes from the mouth, nose and anus. Gas is particularly abundant in the neighbourhood of the tumour, which

on being incised exposes a mass of extravasated blood and lymph exudate. The muscles beneath are of a dirty brown or black colour and readily break down under pressure of the finger. They are infiltrated with gas and crepitate on pressure, and in them the bacilli are present in large numbers. The swelling may occur also in the tongue, pharynx, pleura, lungs, heart, mediastinum, pericardium and the peritoneum, etc. The liver and kidneys may be hyperæmic. The spleen is rarely enlarged. The disease is often speedily fatal.

The carcass should be cremated without being cut in any way. The meat is unfit for human consumption.

RINDERPEST OR CATTLE PLAGUE.

Rinderpest is a contagious disease indigenous to the Asiatic steppes of Russia, India, Persia, China, Burma, Tibet and Ceylon. It has a period of incubation varying from 4 to 8 days; it runs a definite course and frequently terminates fatally. Though bovines are by far the most susceptible, and it is by them that the disease is mainly propagated and in them that the mortality is greatest, infection may be communicated to the sheep, goat, gazelle, deer, camel, giraffe, dromedary and buffalo. The horse, dog, rabbit, bird and man are immune. The earliest symptom is an abrupt rise of temperature (104° F. to 108° F.), usually reaching its maximum on the third or fourth day, falling when other symptoms are developed. In two days the rise of temperature is followed by white eruptions on the inner sides of the lips closely resembling thrush, and there is an alteration in the appearance of the mucous membrane of the vagina. The following day the animal appears definitely ill and its appetite is less. After the fourth day the animal is seriously ill, with drooping head, hanging ears, distressed look, rigors and twitchings of the superficial muscles, failing pulse, distressed breathing, fœtid breath, and discharge from mouth, nose and eyes. On the sixth day the pulse becomes feeble and thready and the limbs weak, the temperature begins to fall also, the abdomen becomes tender, and the preliminary constipation is followed by diarrhœa with much rumbling. When the disease is fully established, the respirations are

often characteristic, consisting of a sudden closure of the glottis, with an audible clicking sound in the course of an expiration and, after a perceptible interval of holding the breath, the expiration is resumed with or without an accompanying moan. The secretion of milk is arrested, often in a sudden and complete manner. The animal grinds its teeth, arches its back, and draws its legs together. In the mouth, in some cases, small round nodules, seldom larger than a millet seed, are observed, through which a yellowish material may be seen. In a few hours the epithelium gives way leaving a small superficial ulcer, which however heals rapidly leaving no scar. The vaginal mucous membrane becomes of a deep dark-red colour.

Post-mortem appearance.—The mucous membrane of the mouth, larynx and pharynx, and of the fourth stomach and small intestine are marked with streaks and patches of red, and the follicles are reddened. The terminal portion of the rectum is especially liable to marked congestion and blood extravasations with more or less desquamation and erosions. The spleen is normal, in strong contrast to that organ in Anthrax, in which disease similar lesions are found in the intestine, specially the rectum. The liver is usually rather pale and soft. The skin may be yellowish, red or dark with a general scurvy condition and eruptions of a rounded wart-like nature on the teats and udder. The blood is at first but little altered, later, however, there is a marked increase of fibrin and a decrease of water and before death it becomes black and incoagulable. In the advanced stages, the flesh is dark, has a disagreeable odour, and may crackle on pressure.

The flesh is unfit for human consumption and should be destroyed.

FOOT AND MOUTH DISEASE.

Foot and Mouth Disease is an acute infectious disease of lower animals, especially ruminants, characterised by a slight fever and the eruption of vesicles or bullæ on the skin and mucous membranes and most usually seen on the feet, mouth and teats. Sheep and pigs suffer less often. Man is susceptible, as are also horses, dogs, cats and fowls, when they are inoculated or fed upon infected material, *e.g.*, milk or other products.

Symptoms.—The incubation period varies from 36 hours to 5 days, and occasionally longer. There is a rise of temperature (102° F.–103° F.), with shivering, dryness and heat of the muzzle, redness of the mucous membrane of the mouth and teats, and impaired appetite, tenderness of the feet and extension backward and shaking of the hind feet in turn. On the second day, the eruption usually appears and the fever falls and bullæ may be found on the inside of the lips and cheeks or on the palate and tongue with, in many cases, a congested areola. These vesicles burst leaving a red sore covered with the remains of the vesicle, suppuration may ensue and, if very severe, abscesses may form in the liver and lungs. On the teats the bullæ appear about the same time, but they are usually smaller than the buccal bullæ. The eruption appears on the feet especially in the interdigital space and, if exposed to dirt, these ulcers may extend and result in the shedding of the hoof.

The Board of Agriculture do not permit infected animals to be brought into public abbatoirs. If the disease is not very severe, the flesh may be passed for food, but the affected parts must be rejected.

EPIZOOTIC PLEURO-PNEUMONIA.

Epizootic Pleuro-Pneumonia is an infectious, febrile disease occurring in cattle, characterised by a prolonged incubation period, an insidious onset, inflammation of the bronchi, lungs and pleura, a profuse exudation into the interlobular connective tissue and chest, and a very extensive area of consolidation in the lungs. Several micro-organisms have been assigned as the cause of this disease.

Post-mortem appearance.—If death has occurred early, the lesions are essentially pulmonary, though the pleura and mediastinum may be implicated. The bronchial, mediastinal and prepectoral glands are enlarged. Later, the glands of the pharynx, mesentery and sublumbar region and groin are enlarged and there is hyperæmia and congestion of the intestinal follicles and intermuscular tissue. The lungs show various stages of hepatization. The flesh is dark.

Pleuro-Pneumonia of cattle does not appear to be conveyed to man. In Germany the flesh is allowed to be sold after it has been thoroughly cooked and left till perfectly cold. The lungs, however, are to be destroyed in every instance. In the early stages of the disease, the flesh appears to be normal in appearance, colour and consistence, later it becomes emaciated, discoloured and flabby. In England, it is customary to condemn only those carcasses which show signs of the disease in the muscular tissue, and to pass the carcass if it presents no departure from natural conditions.

GLANDERS AND FARCY.

Glanders is of importance to the meat Inspector mainly because of the occasional substitution of horse flesh for that of the ox.

Glanders chiefly affects horses, mules and asses. It is also seen in guinea-pigs and field mice, and in carnivora such as dogs, cats, lions and tigers. It also affects man as the result of inoculation. Cattle, swine, the house and white mice are immune.

In the horse one may see either Glanders proper, or Farcy which is a different manifestation of the same disease, or both may be seen together. It may be acute or chronic. It is characterised by a rise of temperature and rigors. The septum nasi and adjacent parts are most affected. The mucous membrane of the nose becomes congested, sometimes only on one side, and later nodules form, which are at first firm and translucent and of a greyish appearance. They are accompanied by a profuse discharge. Later, the nodules soften in the centre and ultimately ulcerate; several small nodules may coalesce to form one large ulcer with a raised margin. The septum is usually first affected and the turbinate bones may become so later. The lungs may show Broncho-Pneumonia and nodules. The Pneumonia may be more or less general and accompanied by intense hyperæmia. The nodules exist in various parts, especially under the pleura; they

may be very small, but are generally larger than the tubercular nodules; moreover, they are fewer in number, and do not show the same tendency to coalesce. There is marked hyperæmia around them. Microscopically, they are seen to consist of, in the centre, leucocytes, chiefly with much exudation of blood-stained fibrinous lymph in the alveoli, the walls of which are very congested. There are no giant cells. Later, the central part becomes granular and opaque, and around this is a zone of leucocytes and epitheloid cells and perhaps a few giant cells. Associated with these lesions in Glanders proper, there is usually some inflammation of the glands in the neck, and mediastinum, and there may be grey or yellowish nodules in the spleen, liver and the testes dyspnœa, difficult deglutition, diarrhœa and emaciation are usually present.

Farcy—or Glanders of the Skin—is less common in chronic Glanders than in acute. Small swellings, which are really localised abscesses, form : the usual site being the limbs, flanks, shoulders, breast and neck. The nodules are known as Farcy buds and vary in size from a pea to a moderate walnut. They cause secondary inflammation of lymph-glands and vessels, forming Farcy pipes or cords. Infection occurs through an abrasion of the skin. The affected glands become large and firm and may at a later stage suppurate and ulcerate. Secondary nodules may occur in the internal organs and on the nasal mucous membrane. Acute Glanders is generally seen in asses, chronic in horses, and both forms in mules.

The disease is due to the Glanders bacillus, which is a minute rod with rounded ends, straight or slightly curved. It is about the same length as the bacillus of Tuberculosis, but is slightly thicker. It is non-motile, non-sporing and Gram-negative. It is sometimes seen in short filaments. In the tissues it lies scattered irregularly among the cellular elements, mostly extra-cellular. It is sometimes seen in the leucocytes and connective tissue corpuscles. It is most abundant in acute lesions and may be difficult to find in chronic nodules. It is not killed at once by drying, but takes some time. It is not easily killed by putrefaction and it offers but a feeble resistance to heat and antiseptics. Injected into the peritoneum of guinea-pigs, it is followed by a very rapid and semi-purulent affection of the tunica vaginalis in 3 to 4 days, and there

are also nodules on the peritoneum. The diagnosis of Glanders is confirmed by the inoculation of guinea-pigs and by the injection of mallein into the suspected animal.

Mallein is prepared by growing Glanders bacilli on glycerine bouillon, subsequently sterilising, filtering and adding a little carbolic acid (·5 per cent.) to prevent decomposition. One c.c. is injected subcutaneously at the base of the horse's neck. The animal's temperature should be taken before injection, and after 6, 10, 14 and 18 hours. In a Glandered animal, *at the site of inoculation a painful local swelling* forms, which is at its maximum size (5 inches) in 24 hours. The temperature rises 1·5 to 2 degrees and is at its maximum in 8 to 16 hours. If the temperature does not go above 1½ degrees, the reaction is doubtful. In unaffected animals, the temperature may rise 1 degree and the swelling may reach 3 inches, but it subsides next day.

Glanders and Farcy are not always acute forms of disease but may both be chronic. The disease is, however, always infective. Indeed, the so-called "Occult Glanders," the only external manifestation being occasional slight nasal discharge, is infective. As Glanders is readily and directly communicated by the nasal discharges, characteristic nodules are soon produced probably in from a few days to a fortnight. The intensity of the disease is proportionate to the rapid formation and softening of the nodules. Man, like the horse, may be inoculated through wounds or scratches, or through the application of the nasal discharge of a Glandered animal to the mucous membrane of the nose or mouth. Acute Farcy in man runs a very rapid course, the average period being from two to three weeks, and perhaps one patient in ten may recover.

At a temperature of 77 deg. Fah. the bacilli grow and develop outside the body, especially in such materials as fodder, manure and stable refuse. However, a temperature of 131 deg. Fah. continued for ten minutes is sufficient to destroy the bacilli.

A stable which has been occupied by a Glandered horse may remain infective for some weeks. It may be efficiently disinfected by good washing with boiling water. A solution of carbolic acid (4 per cent.) applied to the nasal discharge will make it innocuous in a minute.

The duties of the local authority as regards Glanders are to disseminate information about it; to see that all cases are duly reported and dealt with, so as to prevent the spread of the disease; and to inspect more efficiently than is usual, all knackers' yards, and prevent the sale of Glandered carcasses.

The experience of the siege of Paris in 1870 does not show that any ill-effects were experienced as the result of eating horses which had suffered from Glanders and Farcy.

SHEEP-POX.

Sheep-pox is a contagious and infectious disease analogous to Small-pox and Cow-pox. It prevails among sheep and goats and is characterised by early and marked hyperthermia followed by the appearance, on the bare or merely hairy portion of the skin, of diffuse redness, a rounded papular eruption passing into vesicles, pustules, and scabs which ultimately fall off in 15 to 20 days. There are two main forms: (1) malignant, in which the sheep lose their eyes, the wool falls off, the skin cracks in a zigzag manner and the nostrils fill with a fœtid discharge; and (2) benign, in which a genuine blister forms, leaving pits on which the wool never grows again.

Symptoms.—An initial fever followed later by red nodules deeply bedded in the dermis and usually first seen on the inner aspect of the arm and thighs and the cheeks, lips and the under surface of the tail and round the anus. The animal is usually dull and thirsty, and the eyes bloodshot. The papule develops into a flat vesicle which ultimately becomes turbid and, forming a crust, is cast off with the epidermis.

The head is held low, the animal lies by itself in a corner with quick and short breathing, and a discharge from the nose. A secondary eruption may occur, but only papulæ form. The duration is usually about three weeks but, in cold weather, it may reach four.

Post-mortem appearance.—The body is swollen and exhales a fœtid odour. The eyes and nose are closed by a dry discharge. The mucous membrane of the mouth, nose, pharynx, æsophagus, larynx, bronchi and of the rumen are covered with large nodules, and occasionally in the larynx there are ulcers. The lymphatic glands in various parts are enlarged and the subcutaneous tissues are engorged with blood. The pleuræ are often congested and there may be petechiæ, exudation and discoloration. The flesh becomes soft and dropsical.

The flesh should be condemned as unfit for human food. Except in the early stages, the flesh has a most disagreeable odour. In the later stages the flesh becomes soft, pale and dropsical.

Swine Erysipelas.

Swine Erysipelas is a disease of swine, characterised by high fever, great prostration and muscular weakness and a violet hue of the visible mucosæ and a red or violet discoloration of the skin in spots or patches, or even universally, and enlarged lymphatic glands and spleen. The disease is due to a bacillus which is found in small numbers only in the blood and vascular system, but in large numbers in the lymphatic glands, spleen, kidneys and red marrow. The incubation period is about 3 to 4 days. The animal shows signs of fever, the respiration and the heart are accelerated, the animal refuses to move; at first there is costiveness, later diarrhœa. Discoloration of the skin appears early; it may be red or violet, and is noticed round the root of the ears, neck, breast, the inside of the arms, and thighs, abdomen and perineum. The isolated spots may coalesce and form one large mass on the abdomen or the back. The mortality is very high.

Post-mortem appearance.—There are many extravasations into the skin, the lymph-glands are enlarged and become dark-red or almost black in colour. The liver and spleen are congested, as are also the lungs and kidneys. Rigor mortis is not fully developed and, if the disease has been of long duration there is emaciation and dropsy.

Hog Cholera.

Hog Cholera is a contagious disease of swine, of an acute or subacute form, characterised by fever, congestion, exudation, ecchymosis and necrotic ulceration of the intestinal mucous membrane and of the stomach, and by a profuse diarrhœa, enlargement of the lymphatic glands with congestion and blood extravasations, by effaceable blotches and ineffaceable petechiæ of the skin, snout and visible mucosæ, with a tendency to necrotic changes, and less frequently by pulmonary congestion and degeneration and by a high mortality. The disease is due to an actively motile bacillus, mostly occurring in pairs.

Post-mortem appearance.—The spleen is found enlarged, soft and dark.

There is no evidence that the flesh of swine suffering from Hog Cholera causes illness in man. In Germany, the sound

flesh of animals infected may be sold, with a declaration as to its nature, after thorough cooking. The infected parts must be burned or buried. In England, the flesh of diseased animal is considered unfit for food.

COCCIDIOSIS.

Coccidiosis is a disease met with in rabbits, sheep and cattle. It is occasionally seen in man. It is caused by sporosperms. On examination, the liver of the affected rabbit is seen to be studded with nodules which may approach $\frac{1}{2}$ inch in diameter. A common form is the Coccidium Oviforme. It is to be found in the bile ducts, or enclosed in the epithelial cells thereof. If a nodule be opened, clear, ovoid bodies with a capsule of high refraction giving a double contour will be seen. The fæces of affected animals contain these bodies. Somewhat similar forms may be seen in dogs, calves, sheep and birds. Development takes place in the epithelial cells of the liver and bowel.

In so far as suitability for human food is concerned, it is sufficient that the liver and intestines be destroyed.

MALIGNANT ŒDEMA.

Malignant œdema is an acute disease of domestic and wild animals, characterised by a painful and often crepitating swelling in the vicinity of the affected part. The tissues become swollen and, in the case of an open wound, there is a profuse discharge of a yellow, watery or serous aspect, with bubbles of gas possessing a fœtid odour.

The flesh should be destroyed.

RABIES.

Rabies may attack dogs, wolves, foxes, jackals, cats, lions, tigers, pigs, horses, cattle, sheep, goats, deer, rats mice, chickens and pigeons.

The flesh of edible animals should be destroyed.

ACUTE RHEUMATISM OR JOINT ILL.

The animal is lame, or may even be unable to rise. The affected joints contain a clear fluid which may, however, become purulent, and abscesses may form in the neighbourhood of the joint. When the disease is severe, the flesh becomes dropsical, in which case it becomes unfit for human consumption.

PARASITIC DISEASES OF ANIMALS.

There are 3 main types concerned : the Trematodes, Cestodes and Nematodes.

Trematodes (flukes).	Cestodes (tape worms.)	Nematodes (round worms).
1. Short flat worms.	1. Long flat worms.	1. Long and cylindrical.
2. Alimentary canal present.	2. No alimentary canal.	2. Canal present.
3. Nearly all are hermaphrodite (Bilharzia, not so.)	3. Hermaphrodite.	3. Sexes separate.
4. Skin chitinous.	4. Skin cellular.	4. Skin chitinous.
	5. Adult worm inhabits the alimentary canal.	

It is possible to refer only to a few of the more common worms which are found in animals and which in turn affect man. Those mentioned are more or less typical of their class, and are mentioned as such and not necessarily because they are found in India.

FASCIOLA HEPATICA (THE LIVER FLUKE).

This worm belongs to the order of Trematoda and its geographical distribution is universal. Its hosts are man, cattle, sheep, swine, and sometimes the horse and rabbit and its habitat is the liver and bile ducts of the affected animal.

The Distoma Hepatica are flat, conical worms, longer than broad. At the anterior end is situated the mouth surrounded by a sucker. A second sucker is situated in the median ventral line. The surface of the flukes is generally more or less covered with minute spines.

The digestive tract consists of the mouth and pharynx, below which is a circular muscle which cuts off the œsophagus from it. Near the ventral sucker, the œsophagus divides into two blind sacks which run parallel to the sides and give off branches which again divide. A few short branches are given off internally. None have an external opening. A central canal runs from the junction of the upper and middle third to the posterior end of the worm, terminating in the foramen caudale. At the anterior end, it has three branches, one medial and two lateral; the main trunk gives off branches which sub-divide.

Genital organs.—The worm is hermaphrodite. The genital pore is in the median line, just above the ventral sucker. The penis is in a pouch which also encloses the receptaculum seminalis into which run the vasa deferentia from the testes which are two in number. The female organ comprises the vaginal orifice which is very small and is situated in the genital pore near the penis. The uterus is much coiled and lies just above the testes.

Life-history.—This is very complex, for the adult parasite, instead of producing young similar to itself and capable of developing into adults in cattle, produces eggs which develop into organisms totally different from the adult form, living a parasitic life in other animals. The ova are oval in shape and about ·14 m.m. by ·11 m.m. in size. They are ciliated and have an operculum and contain an embryo. The eggs escape from the uterus of the adult and are carried to the intenstine of the host with the bile, and then pass out with the fæcal matter. Many of them become dried and undergo no further development, but others are dropped in the water of marshes or into damp soil. After a longer or shorter time, a ciliated embryo is developed, the time varying with the temperature: at 20° to 26° C. it takes 10 days to 3 weeks, at 16° C. 2 to 3 months. As long as the eggs remain in the dark, the miracidium will not escape from the egg. When, however, the free, swimming, ciliated miracidium does escape it swims in the water and seeking out certain varieties of snails, attacks

them and, seeking the liver there, develops into a sporocyst which grows slowly at first and then more rapidly. When they are about two or three weeks old, rediæ escape from the sporocyst and increase in size. The redia has a mouth, pharynx and a blind intestinal canal.

The redia, as well as the sporocyst, may be looked upon as a female organ and in its body cavity are found a number of germ cells which develop into cercariæ, which resemble the adult in having suckers and an alimentary canal; but they have no genital organs. They have a large tail. When developed, they leave the body of the sporocyst or redia and the snail, and swim about in the water. After a time they attach themselves to blades of grass, etc., and lose their tail. They now remain quiescent until they are swallowed by some other animal, when, *via* the gall-ducts or possibly the portal veins, they reach the liver where they develop into the adult hermaphrodite worm. This curious development lasts about 10 to 12 weeks, and there is a constant potential increase in the number of individuals; for the sporocyst may give rise to 5 to 8 rediæ and each redia to 12 to 20 cercariæ and each adult to from 37,000 to 45,000 eggs. This fertility is necessary because the life-history is complicated, and comparatively small chance exists for any one egg to complete its life-history. As a general rule, it can be said that the disease is found usually on the lowlands, marshes, valleys, etc.

If the disease be not extensive, only the liver of the sheep need be destroyed.

If there is marked anæmia, cachexia, general weakness and bile discoloration of the tissues, the flesh should not be placed on the market.

In the sheep the worm is easily demonstrated by pressing on the bile ducts.

CESTODES OR TAPEWORMS.

The more important cestodes, as far as meat inspection is concerned, are three in number, *viz.*:—

(1) Tænia Mediocanellata (Synonym, Tænia Saginata),

(2) Tænia Solium,

(3) Tænia Echinococcus.

The cestodes are long, ribbon-like worms. They exist in different forms in the alternate hosts. The adult tapeworm inhabits the intestinal canal.

TÆNIA MEDIOCANELLATA.

The Tænia mediocanellata or *Saginata* is the commonest tapeworm found in England. It is distributed over the whole world, being found in Europe, Asia, Africa, America and Australia. Its chief host is man and its intermediate host is the ox, where the worm is encysted (cysticercus Bovis).

Description of the adult worm found in man.—This tapeworm can approach 25 feet in length. The whole body of the tapeworm (the strobila) consists of a head and neck (the scolex) and a series of segments (the proglottides).

The head is somewhat square-shaped, about $\frac{1}{8}$th of an inch in size, and is provided with four suckers. There are no hooklets and no rostellum. There is much pigmentation, however. Growing out from the posterior end of the head is the thin neck which merges into the segments or proglottides. Each proglottis is hermaphrodite. The male organs are the testes and vasa deferentia. The female organs are the ovary, uterus and vagina. The uterus is composed of two main branches and a large number of ramifying lateral branches, which are 20 to 30 in number and are so closely packed as to appear parallel. The genital pore is sometimes alternate but may vary greatly.

The proglottis has a narrow anterior part and a broader posterior. In all there are a vascular apparatus and sexual organs.

The ova are impregnated in the uterus and, after a lapse of time, pass down to the vagina.

The Tænia mediocanellata produces about 1,200 segments and from about the 600th, each segment is sexually mature.

Life-history.—Starting with the adult tapeworm in the intestine of men, the egg escapes from the uterus of the worm and passes out with the excreta, or segments containing eggs may break loose and pass out. In either case, the eggs become scattered upon the ground or in water and reach cattle, by their food or drink. Upon arriving in the stomach of the ox, the

egg shells are destroyed. The embryo then bores its way through the intestinal walls with the aid of six minute hooks with which it is provided and wanders to the muscles where it rests, or if it bores its way into a vessel it may be carried by the blood to any organ in the body. When it comes to rest, it loses its hooks and increases in size, developing into a small round bladder worm. The head of a future tapeworm is then developed in an invagination of the cyst wall, and the complete organism thus formed is known as a cysticercus or bladder worm. The total time taken is about 7 to 18 weeks.

The Cysticercus bovis has been found in the skeletal muscles (measly beef), heart, the adipose tissue round the kidney, subperitoneal connective tissue, lymphatic glands, brain, lungs and liver. It lies between the muscular fibres. It is white or grey in colour and has a small yellowish spot on it due to its invaginated head. The bladder contains but little liquid, and has only one scolex.

These bladder worms are specially seen in the jaw-muscles, diaphragm, tongue and shoulder. The breast, eyelids and heart are also frequently affected.

The only parasites likely to be confused with the cysticercus are (1) the Cysticercus tenvicollis which, however has 28 to 40 hooklets and, moreover, is found under the serous membranes of the body cavity and not in muscles, and (2) the Tænia echinococcus in which either the head is absent, or there are numerous armed heads in brood capsules, the cuticle is thick and laminated and its form is round, whereas in the Cysticercus bovis the form is oval, the cuticle thin and there is an unarmed single head.

TÆNIA SOLIUM.

The Tænia solium is very common in Ireland and Germany. The adult stage is seen in man, and the larval (the Cysticercus cellulosæ) in the pig.

The adult worm as found in man.—The head is smaller than that of the Tænia mediocanellata, measuring about ½ inch. It has four suckers and a rostellum, at the base of which are two rows of hooklets numbering about 26 and

rarely exceeding 30. It is smaller than the Tænia media and seldom reaches more than 15 feet in length. The proglottides resemble those of the Tænia media in shape, but are smaller. The genital pore is lateral and alternates regularly. The uterus is less branched, having about seven to ten branches only. There are about 850 segments; each segment after the 450th is sexually mature.

Life-history.—The life history is exactly the same as in the Tænia mediocanellata, except that the pig, and not the ox, is the intermediate host and that this bladder worm is occasionally found in man. It is rare to find more than one T. mediocanellata in the same patient, but several cases are on record of two or more T. solia being found. The pork bladder worm is larger than the beef, reaching a maximum of half an inch. It is usually found in the muscles of the tongue, neck, shoulder (measly pork) and in the liver and kidneys, abdomen, jaw, inter-costals, diaphragm, pectorals and the adductors of the hind legs. The parasite in the pig which is most likely to be confused with the Cysticercus cellulosæ is the Cysticercus tenvicollis, which is not transmissible to man. It is larger and has more hooks (28 to 40) and is found under the serous membranes of the body cavities and not in muscles.

Both measly beef and measly pork should be condemned.

TÆNIA ECHINOCOCCUS (CESTODE).

The Tænia echinococcus is perhaps the most important parasite in meat inspection.

Its larval life is spent in any organ, but more particularly in the lungs and liver of man, cattle and sheep. The adult stage is seen in dogs, but not in man; when eaten by dogs the hydatid develops into an adult tapeworm. It is also seen in the dingo, jackal and wolf.

The disease in man caused by the larval stage of this worm is known as Hydatid Disease. It is very common in Ireland, India and Australia and is also seen in England.

Description of the adult worm.—The head is much smaller than that of the two preceding worms. It is about $\frac{1}{40}$ inch. There is a rostellum and also a double row of hooklets of two different sizes. In all, the hooklets number about 30 or 40. There are also four suckers.

Proglottides.—There are four segments only, of which the 4th alone is mature.

The worm is about $\frac{1}{4}$ inch long and the structure is but ill-defined. The uterus is central and presents a rosette appearance. The genital pore is laterally placed.

Life-history.—Starting with the adult worm in the small intestine of the dog, wolf or jackal, the eggs are scattered on the ground and are swallowed by the intermediate hosts (man, cattle, sheep, swine) in water, or food. Upon arriving in the stomach, the six-hooked embryo escapes from the egg shell and wanders, or is carried to various organs of the body, *e.g.*, liver, lungs, ovaries, bones or skull, where, losing its hooks it develops first into an acephalocyst, which may develop "heads" (scolices) in it later; these heads when swallowed by a dog, wolf or jackal, develop once more into adult worms.

The cyst after a short time is seen to be composed of two layers: (1) a striated chitinous external layer, and (2) a parenchymatous layer of two parts, a superficial granular and a deeper cellular containing a water vascular system and muscular fibres.

Soon this inner parenchymatous layer becomes vesiculated and very granular here and there, a small cavity forms in which develops a scolex with a row of hooklets and four suckers. This may occur at several places. These daughter cysts separate and go into the body of the main cyst. If any of these scolices are eaten by the dog, etc., they develop into an adult tapeworm.

Sometimes a cyst remains single, and at other times it produces a large number of daughter cysts (seen commonly in man). Sometimes the daughter cysts are contained in fissures in the other layers, finally becoming free outside (seen in cattle—Ecchinoccus veterinorum). Sometimes many cysts appear which are not connected together, called Echinococcus multilocular; lastly occasionally in the liver, lungs and peritoneum of cattle a large cyst is found without any head or hooklets in it. It is then recognised as a hydatid by the presence of the chitinous external layer and of a fluid with low specific gravity, containing albumen in it.

This variety of cyst is known as an acephalocyst.

It must be remembered that the daughter cysts may give rise to grand-daughter ones.

Organs infected with the Echinococcus should be most carefully destroyed, so as to prevent dogs, etc., eating them.

In a country where the disease is prevalent, the companionship between man and dog should not be too intimate as man gets infected by using the same plates for food as their pet-dogs, or by kissing infected dogs. Dogs are very fond of licking their anus, and thereby transferring the ova to their mouth.

Under no circumstances should dogs ever be allowed into a slaughter-house.

All stray and ownerless dogs should be destroyed. This is a most important point in the prevention of the spread of this disease, and should never be neglected.

Another member of the cestode class (though not transmitted by meat) is:—

BOTHRIOCEPHALUS LATUS.

Bothriocephalus Latus is seen frequently in Russia, Sweden, Switzerland and Japan. It is rare in England. It is a very large worm and may attain 25 feet in length; it is reddish grey in colour.

The adult life is passed in the intestine of man, the dog and the cat. Its intermediate host is the common pike, the ling, the perch, and several members of the genus salmo.

Description of the adult worm as found in man.—The head is long and narrow. There are no hooklets, no rostellum and no suckers, but in place of the latter are two lateral slits or grooves like suckers. The proglottides number about 4,000 and are sexually mature from about the 600th. They are short and broad. The genital pore is central and the uterus is rosette-shaped.

The cystic stage is not fully known. The larvæ which escape from the operculated eggs are ciliated and swim in the water for a long time, until eaten by certain fish (pike, perch, etc.), when the cilia and 6 hooklets are lost. It is subsequently conveyed to man in his food.

TRICHINOSIS (NEMATODE).

The disease is due to the presence of the Trichina spiralis. This parasite is found affecting man almost throughout the world, especially where much pork is consumed. The natural host would appear to be the rats and the disease is kept up by the habit they have of eating their dead. Pigs eat rats and perhaps portions of other infected pigs, and finally man eats the pig. The Trichina spiralis in its adult stage lives in the small intestine. Its larval stage is passed in the muscles. It is communicated to man by eating the flesh of pigs and the disease Trichinosis is due to the emigration of the embryo. Trichinæ present in the flesh of the pig, if encapsulated, may be seen with the naked eye as small round white specks, but often a microscope is necessary. To prepare a section, take a thin slice of flesh place it in some liquor potassæ (1 in 9) and let it stand for a few minutes till the muscle becomes clear. The white specks stand out clear and the worm can be seen coiled up inside. If the capsule is too dense to allow the worm to be seen, add a drop or two of acetic acid. The cysts lie with their long axes parallel to the muscle fibres. The larvæ in the muscle are about ·6 to 1 m.m. in size; they lie coiled up in an oval capsule, which is at first translucent but later opaque and perhaps calcified. At either end of the capsule are small fat globules. When the diseased flesh is eaten by man, pig or rat, the capsule is dissolved and the embryo is set free. The larvæ develop in the intestine and become sexually mature in 2 to 3 days, and the female, after impregnation, produces about 1,000 eggs. In about one week these eggs set free small worms, and the male and female adult worms disappear. The adult male measures about 1·2 to 1·5 m.m. and the adult female about 1·5 to 2·0 m.m. As soon as born, the embryo trichina leaves the intestine and (*via* the peritoneum and connective tissues) in all directions penetrates to and lodges in the muscles, especially in the diaphragm and tongue muscles near their tendons. From

the time of ingestion of the food to the lodgment of the worms in the muscles, about two weeks elapse. Sometimes 2, 3 or 4 worms may be seen in one capsule. In 3 or 4 weeks these larval worms become fixed in their final position in the muscles and do not undergo any further development. The capsule gradually becomes thicker and may become calcified; in man this may occur in about 4 to 6 months, but in the pig, it may be delayed for many years. Once lodged in the muscles, the larvæ may live for an indefinite number of years. Experimentally, one can infect guinea-pigs, rabbits and cats and, with difficulty, dogs. In the pig, trichinæ, like the cysticercus, cause few, if any, symptoms. The animal may appear quite healthy and well nourished.

Mode of Infection.—The disease is conveyed by the ingestion of imperfectly cooked pork. If all parts of the joint are thoroughly cooked, the danger is perhaps remote. Salting and smoking are quite insufficient to afford protection.

Symptoms, etc., produced in man.—A few days after eating infected pork, there is pain in the abdomen, loss of appetite, vomiting, and sometimes diarrhœa: the latter is by no means always constant, but it may be very severe. In addition there may be general debility and pains in various parts of the body. Between the seventh and tenth day, but sometimes not till the fourteenth, chills may occur, but not commonly. There is generally fever, sometimes of an intermittent type and sometimes of a remittent type, pain on pressure and movement of muscles, accompanied by swelling of the same and if the muscles of the jaws and of the larynx and pharynx are involved, there is some difficulty in mastication, deglutition and respiration. In severe cases the involvement of the diaphragm and intercostal muscles causes dyspnœa which may prove fatal. Œdema may occur often early in the face and later in the extremities when the stiffness and swelling of the muscles are at their height. There may be profuse sweating, tingling and

itching and occasionally Urticaria has been seen. The general nutrition is impaired and there is emaciation and Anæmia. The patella reflex is absent. The sufferer is usually conscious except in very severe cases when there is delirium, dry tongue and tremors as in Enteric Fever. Bronchitis, Pleurisy and Pneumonia may supervene and prove fatal. The prognosis is variable, the mortality ranging from 2 to 30 per cent. In mild cases, recovery occurs in from 10 to 14 days. In the more severe cases, it occurs in from 6 to 8 weeks. The prognosis is more favourable in children, and when early diarrhœa and moderately severe gastro-intestinal disturbances are manifested. Constipation is unfavourable. The most important diagnostic points are the pains and swellings in the muscles, the presence of œdema and the shortness of breath.

Trichinosed flesh should invariably be condemned. In the pig the capsules are specially to be seen in the tongue, diaphragm and intercostal muscles.

PRESERVATION OF FOOD.

The preservation of perishable food is of very ancient origin, but the science of Bacteriology has helped us to improve and perfect the old methods. The use of sugar, salt, vinegar and smoke are old domestic methods. Formerly chemicals which have a deleterious effect were used blindly and liberally to preserve any foods, even those in a state of decomposition. The object of preservation should be to keep the food in as fresh a state as possible, without diminishing the nutritive properties and without adding or producing any injurious effects. The principal object of preserving food is to make it available in times of scarcity, and for exportation to places where it is scarce.

The usual methods adopted are cold, drying, salting, smoking, heat and exclusion of air by tinning, and the use of chemical substances.

Refrigeration and sterilization are the best methods of preserving food as they cause comparatively little alteration in it.

Preservation by Cold.—This can be done in two ways, either (1) by freezing the foodstuffs and keeping them so; or (2) by keeping them in a chamber the temperature of which is at or just below freezing point. Cold does not kill but only hinders or prevents the growth and multiplication of bacteria. The effect will vary with the temperature. While pathogenic bacteria do not develop at the low temperature of the refrigerator, many saprophytic bacilli and moulds may do so at 0°C. Refrigeration is one of the best methods of preserving foodstuffs, and it is possible by it to transport fresh and wholesome food from and to the tropics.

Frozen meat is often very tender and of excellent quality, though sometimes it is lacking in flavour. The juice is less abundant and less red in colour than that from fresh meat, and, according to Maljean, the corpuscles in the juice of the former are more or less distorted in form and decolorised. Bacteria in general, offer great resistance to cold, which, while not killing them, prevents their development; this at any rate is more particularly the case in regard to the putrefactive bacteria. The flesh has a uniform pink appearance and the fat is not stained. Refrigerated meat can be recognised by the fact that the fat is pinkish in colour, while the surface of the meat presents a dull appearance. When frozen meat thaws, there is much oozing of fluid, the flesh has a parboiled appearance and the fat has a deadly white colour. It is important, especially if the piece is a large one, to ascertain the condition of the interior, as the outside may be apparently all right and yet the interior be decomposed. This can be done by inserting a knife or thick skewer and, on withdrawal thereof, noting the presence or absence of any offensive smell. This should be done especi-

ally in the neighbourhood of joints and bones, as putrefaction sets in early there. In cold storage plants, moisture condenses on the surface of the articles stored and in the case of meat the water will dissolve some of the proteins, extractives and salts and form a nice medium for the growth of bacteria. It is, therefore, desirable that meat should be first dried in a current of dry air which will desiccate the surface and prevent the inward growth of bacteria from the surface.

On removing the cloth, in which refrigerated meat is wrapped, a disagreeable smell may be noticed. The meat should not be too hastily condemned on this account, as the smell may be due to the wrapper and not to any deeper-seated trouble. Klein has published a report on the nature of the black spots occasionally seen on chilled beef. It appears that the meat shipped to England from the Argentine occasionally develops circular black spots which may be in groups or isolated. On the lower or thin parts they are seen in the fascia, and on the thick parts, in the fatty portions and in the fat belonging to the inner surfaces of the flanks. According to Klein, they are due to a mycelium of a fungus of the nature of an odium, which he has proposed to call Odium Carnis. It forms oval gonidia either by short lateral branches of the free hyphæ or along and at the ends of the superficial threads in the fatty tissues. The oval gonidia are capable of multiplying in the manner of yeast cells. He is of opinion that the material of the black spots is harmless to the animal body, a view which is confirmed by direct experiment; further, that the presence of the mycelium does not in any way alter the normal character of the tissue elements themselves, either those among which the mycelium is situated or those beyond its extension.

Preservation by Drying.—Drying, dessication, or evaporation is an old and advantageous method of preserving food. It can be applied to meat, vegetables, milk, nuts, eggs, and to almost every variety of watery food. The effectiveness of drying depends on the degree

of dehydration. With the elimination of water, micro-organisms have no moisture for growth and development and hence the keeping quality of the food is improved. The reduction in weight also facilitates handling and distribution. Most dried foods are cooked before eating and hence this is a further sanitary safeguard. Each food must be dried by a process best suitable for it. The primitive method of sun drying has now been replaced by drying in a current of dry warm air, or on heated and revolving metal drums, or in vacuo. Drying has little or no effect on the vitamins, unlike oxidation. Vitamin A and B are unaffected, and dried milk can be a source of Vitamin A. Vitamin C is however, affected, and a diet of dried foods may give rise to scurvy. Dried meat can keep for a long time but loses its natural flavour.

Preservation by Salting.—Salt acts by removing water from the flesh and also as a mild antiseptic. As it frequently causes discoloration, potassium nitrate (saltpetre) is added in the proportion of 1 part of saltpetre to 32 parts of salt and 2 parts of sugar (Brine). Sugar is added in order to hinder putrefaction. Care should be taken not to add too much, as evidence exists to show that saltpetre has the power of inducing irritation and inflammation of the mucous membrane of the intestines. The nutritive value of flesh when salted is lessened. One must examine the meat very carefully to see if it has gone bad, which occurrence would be indicated by the meat being paler than usual, with green patches here and there, and the presence of an unpleasant smell. Streptococci, Tubercle bacilli and the spores of Anthrax can retain their virulence for months in salted flesh.

Used brine is sometimes poisonous, due apparently to the products of the decomposition of animal substances which have passed into it. This occurs in cases where the brine has been used for several relays of meat.

Instead of curing meat by placing it in brine, the same object can be effected by what is known as dry salting. In this the flesh is treated by repeated applications of salt and saltpetre to the external surface. Klein discussed the nature and cause of taint in miscured hams. The hams examined were dry-cured only, no other method of salting, injection or pickling in fluid being used. The hams had a distinctly putrid smell, the muscles were more or less discoloured, in the slightly tainted part the characteristic red tint of well-cured muscle had given way to a pale or dirty grey tint, while in the strongly tainted parts the colour was dirty grey to green and, moreover, the muscle tissue was swollen and soft like jelly. On microscopical examination, small linear clumps of tyrosin crystals were found, many being seen near blood vessels. The muscle fibres had lost their transverse striations, and contained numerous empty spaces (gas bubbles). These all indicated putrid decomposition of the protein constituents of the muscle. The reaction was alkaline to litmus. In all cases, the decomposition was most pronounced at and around the knee. The taint started here and gradually progressed towards the femoral and gluteal regions. In badly miscured hams, the condyles of the femur, patella, condyles of the tibia, crucial ligaments, semi-lunar cartilages, connective tissues, tendons and muscles adjoining the capsule were green and very putrid to the smell. The essential cause in all hams examined was one and the same species of a cylindrical microbe, found in great numbers in the tainted part and proportionate in number to the degree of taint. All the affected parts contained the organisms. The free surfaces of all parts within the articulation were covered with a slimy moist film which, when examined under a microscope, was seen to be composed of a continuous mass of the microbe which had been named the Bacillus Fœdans.

Preservation by Smoking.—The smoking of meat, fish, ham and other products is effected by submitting them to

the smoke of a smouldering wood fire usually after a preliminary salting. This method acts mainly by reason of its drying effect, and to a less extent on account of the antiseptic action of some of the constituents of smoke *viz.*, acetic acid, creosote, formaldehyde and other germicidal substances. As the penetrative effect of smoke is not deep, putrefactive changes may occur in the interior. Smoke does not kill many of the bacteria but only retards their development. Subsequent to smoking certain articles now appear to be subjected to an artificial colouring process.

Sterilization by Heat.—Steam is used to sterilise foodstuffs which are placed in cans, or in glass or earthenware jars. Canned foods come in handy not only during voyages or war, but in our homes when food cannot be prepared at the spur of the moment. In the process of canning the material is placed in the can and the lid is soldered on. The small blow-hole in the centre of the lid is then soldered and the can is placed in a steam retort (115° C.) for an hour or two. The can is then removed and the solder seal quickly melted off to allow the expanded gases to escape and then resoldered. In recent years fractional sterilisation has been adopted whereby the cans are given a second and even a third heating after twenty-four hours in order to kill the bacteria developing from the resisting spores. Provided wholesome food is used and the process of sterilisation is properly conducted, the cans should keep well for a long period.

The various causes which may lead to the spoilage of canned food are: (1) the unwholesomeness of the original food, (2) defects in the can, (3) uncleanliness in preparation, (4) carelessness in sealing, (5) imperfect sterilization resulting in decomposition of the material.

Poisoning as the result of eating tinned foods may arise, due to (1) the decomposition of the flesh owing to imperfect sterilization or incomplete sealing of the tin, (2)

the flesh having been poisonous originally as is sometimes seen in fresh flesh from exhausted animals and certain fish, (3) the use of chemical preservatives, (4) the addition of harmful colouring matter, (5) metallic contamination due to the solution of tin, lead, and even arsenic from the tin or solder.

The most dangerous tinned foods are those containing much moisture, for example: Milk, salmon, lobster, and mixtures of meat and vegetables. The simpler the preparation the better does it stand the climate. Beveridge states that in warm climates no tinned meat stored in the open, exposed to varying temperature and the sun and the rain, should be kept for more than one year.

The cans should be properly coated inside with tin and there should be no flaw visible with a magnifying glass lest the iron should rust through and form a tin-lead, or iron-tin couple which with the acid juices may cause a galvanic current. Potassium Ferrocyanide solution will show a bright blue precipitate with the exposed iron if even a pin hole flaw is present. The tin should not contain more than one per cent. lead, and the use of terne-plate (two of tin and one of lead) should be prohibited. The solder on the outer side should not have more than 1 per cent. of lead and should be kept entirely on the outside and not allowed to get in. For preserved fruit in acid juices (*e. g.* vinegar, plum and asparagus juice) the can should be lacquered inside.

A tin, the contents of which are sound, usually has concave surfaces owing to the partial vaccuum caused during sterilisation and emits a dull sound on percussion. In damaged cans gases, due to decomposition, press on the lids and make them first flat and then convex on the outside. Percussion will then yield a hollow sound. The tins can be tested by puncture under water, when with good tins the water will be sucked in, whereas if the tin is slightly blown or bulged a few bubbles of gas due to putrefaction will escape.

The tins may bulge due to (1) decomposition of the contents and the formation of gases, (2) rough handling of the tins, (3) the freezing of the liquid and semi-liquid contents, (4) gases formed by the electrolytic action between the metals and the acids formed by the growth of bacteria *e.g.* in milk.

Dented tins may be passed, if they are intended for early consumption; otherwise, if kept too long, they are apt to rust and perforate and so prepare the way for the decomposition of the contents.

Re-soldering of tins is indicative of the tins having been tapped to allow the accumulated gases due to decomposition to escape, and then resealed. Two solder points are, therefore, suspicious but some manufacturers find it more convenient to make a second blow-hole to let off the gases during the process of canning, rather than to open up the original solder. Fraudulent dealers may melt the solder on the original blow-hole and then renew it and thus avoid any clue. A splash of solder on the tin may resemble a second solder point. The presence of moulds is sufficient to condemn the contents, because, even if not definitely harmful in themselves, they indicate faulty sterilisation and, moreover, they impart an unpleasant taste to the contents, and may cause diarrhœa.

Metallic tin, lead, rarely arsenic, copper, or zinc have been obtained from the juices of preserved fruit. Metallic tin may be dissolved by the organic acids of preserved fruit and vegetables or by oil in canned sardines and lobsters and should never be allowed to exceed 2 grains per pound. A flaw in the tin may cause an iron-lead couple to be formed which will lead to further solution of tin. The tin coating will be found discoloured in patches.

A few instances of poisoning have been recorded where 15 to 20 grains to a pound of tin were detected. Metal is more likely to be taken up by the acid foodstuffs *e.g.* jams, fruits, and vegetables. On opening certain tins, *e.g.*, of marmalade, rhubarb, tomato soup, etc., a black appear-

ance may be noticed ; this is due to the action of the vegetable acids on the tin plating : if only slight, and there are no fermentative changes present, it may be neglected.

Lead may be dissolved from the solder or varnish used in painting the inside of the tins. Cans with only one joint and a solder trap which prevent the possibility of solder entering into the can are sometimes now used. Glass containers with air-tight metal caps and rubber washers are very advantageous for preserved fruit as they are free from tin and lead, but the heat for sterilisation must be lower to avoid breakages.

Even in the absence of pathogenic bacilli in canned meat and fish, certain spores which are extremely resistant to heat *e.g.*, B. Cadaveris, which have withstood the process of sterilisation may be present. They remain inert for a long time, but when stored in a room at a temperature of 98° F. they may develop and decompose the meat and render it unfit for human consumption. It is therefore recommended that the temperature of sterilisation should be 245° F. Savage found that canned meat and fish often contained sporing aerobic bacilli and micrococci derived from the original, material. The absence of oxygen hindered their development. The conditions under which such food eventually decomposes would depend on the nature and degree of bacterial contamination, the access of air, the efficiency of sterilization, and the temperature of the air where the cans are placed. Cans which have been passed as good by the manufacturers may therefore go bad after some months on account of the temperature of the air. Canned tins should bear the name of the manufacturer, the date of manufacture, and a warning that the contents should be eaten on the day of opening as subsequently bacteria may develop and form toxins.

In selecting tinned articles, only those contained in tins of good quality and bearing the name of the maker should be chosen, as poor quality tins usually contain bad material.

No chemical tests are of any practical use, but acid juices and oily liquids should be examined quantitatively for tin. General physical signs may afford some clue of early decomposition. The odour may be changed, there may be loss of firmness or resistance to pressure, and there may be a change of the natural colour and increased opacity of the liquid The tin coating may also be discoloured in patches.

Preservation by Means of Chemical Substances.—The chemical preservatives most commonly used are Borax and Boric acid, Salicylic acid and Salicylates, Benzoic acid and Benzoates, Formaldehyde (a 40 per cent. solution of which is sold as Formalin), Hydrofluoric acid and Sodium fluoride, Sulphurous acid and Sulphites. Besides these there are certain others, *viz.*, Sugar, Salt, Vinegar, Spices, etc. which are not regarded as chemicals but as natural preservatives or condiments.

The preservation of food by chemicals used formerly on a very large scale is at present on the wane, as laws prohibiting their use are being enforced everywhere. In the small quantities they are used in foods, they have little or no germicidal power but act as antiseptics, restraining the growth and development of bacteria and moulds. The chief reason adduced against the use of preservatives is the ill-effects on health of the daily ingestion of small quantities of these chemicals. Some of the chemical preservatives in use are known to produce in large doses injurious symptoms such as headache, vomiting, loss of appetite, diarrhœa, albuminuria, depression, skin eruptions, etc. Though it is unlikely that such symptoms of acute poisoning are likely to result from the small amounts taken in food, yet the prolonged use of such preservatives may insidiously bring about dyspepsia, flatulence, diarrhœa, renal derangement, wasting and general impairment of health. A small amount daily in several foods will mean the consumption of considerable quantity in the course of an ordinary day's diet. Thus though the amount present in any particular food may not

derange health, the total amount taken in various articles of a meal may do so. Moreover the addition of preservatives not only facilitates the careless and improper methods of food production but renders it possible to preserve food in an incipient stage of decomposition for some time with a false appearance of freshness and wholesomeness. The irritant effects of a preservative which may be of not much consequence to a person in normal health will affect adversely an invalid specially one with gastro-intestinal or kidney complaints. The question of idiosyncrasy which is a peculiar susceptibility of certain persons to drugs has also to be remembered specially on account of the accumulative effects of some preservatives.

Those who are in favour of the use of chemical antiseptics maintain that: (1) much food would go to waste without their use, (2) the injury arising from the consumption of fermenting and decomposing food would be much greater than the ingestion of the chemicals used to check such deterioration, (3) there is as much evidence of the harmlessness of these agents as of their harmfulness. None of these arguments are of much weight and the Departmental Committee in England on the use of Preservatives and Colouring matters in Food, in their final report after due consideration of the effects of the various preservatives on the consumer and of their relative harmfulness, have reported that the use of the preservatives should be prohibited except in a few cases. With appropriate care in preparation of foodstuffs, the application of two efficient and wholly unobjectionable processes of preservation of food, *viz.*, refrigeration and sterilisation by heat, and improved methods of transport, storage, and distribution, the use of preservatives except in few cases, is unnecessary. The Departmental Committee have classified preservatives into three groups according to their relative degrees of undesirability :—

GROUP I. Formaldehyde and its derivatives; hydrofluoric acid, its salts and derivatives.

II. Boron preservatives, salicylic acid and its salts.

III. Benzoic acid, sulphurous acids and their salts.

Group III is supposed to be the least harmful and in such cases where the use of preservatives is imperative only those in the last group are recommended.

Formaldehyde was formerly used very largely for preserving milk and other foodstuffs but is most objectionable and is now prohibited. It is a powerful disinfectant and irritant and by retarding the digestion of proteins by the gastro-intestinal juices may cause dyspepsia and disturbances of digestion. Schryver found that formaldehyde could be recovered not only from the various parts of surface of the meat, but also from parts below the surface, especially where the muscles had not been covered by connective tissue or fat. He found that boiling and roasting appeared to reduce or even remove the formaledehyde; grilling however appeared to make it penetrate further into the substance. Articles like mincemeats, fish, kidneys, etc., which expose a large surface in proportion to weight, cannot be exposed to fumes in formalin safes without absorbing relatively large quantities of the drug.

Boron compounds are the most commonly used for all the preservatives. Boric acid and borax are very largely used for preserving butter, cream, margarine, sausages, potted meat and fish and some beverages. The amount used varies from a trace to 35 grains per pound (0·05 per cent.) but excessive amounts up to 175 grains have been detected in butter, bacon and margarine. Much conflicting evidence exists in regard to the influence of boron compounds on health. In some individuals quite small doses may produce gastric irritation, and albuminuria specially in those with bad kidneys. Experiments of Heffter, Sonntag and Rost show that small doses of Boric acid can produce irri-

tation of the alimentary canal. As Boric acid is excreted more slowly than absorbed, it is liable to accumulate in the system and cause decreased absorption of fats and nitrogenous substances. The Departmental Committee have prohibited the use of Boric acid in any foodstuffs, and its prohibition is well justified.

Salycilic acid and salycilates have been found in beer, wines, milk and non-fermented beverages and cordials and coffee extracts. They are rarely used in solid foods, though they have been detected in sausages. The amount required is about 5 to 8 grains per pint. The objection to the use of salycilates is that they cause both the acute and chronic types of poisoning specially in the case of aged, feeble and susceptible persons. Prolonged use may give rise to loss of appetite, diarrhœa, skin eruptions, irritation of kidneys and mental depression. Their use is prohibited.

Benzoic acid and benzoates are considered the least harmful of the preservatives and are placed in group III together with sulphites. Benzoic acid is permitted in coffee extracts up to three grains per pound, in non-alcoholic wines and cordials, and fruit juices up to 5 grains per pint, and in sweetened mineral waters and brewed ginger beer up to one grain per pint.

The human organism is capable of rendering harmless a relatively large amount of Benzoic acid. Very large doses may set up digestive troubles but in the experiments, Chittenden failed to prove any deleterious action on persons in health, of doses larger than are likely to be present in food. It is possible that they may affect adversely invalids and those with gastro-intestinal and kidney complaints.

Sulphurous acid and sulphites are largely used to preserve beer and alcoholic wines and to some extent non-alcoholic drinks, fruit and fruit juices, dried fruits and sausages. In meat shops they are applied as a wash to the surface of the meat by butchers and some poultry dealers.

In the case of wines and fruit juices besides being actually added in the course of manufacture, the vessels of preparation and storage are treated with them. Though Sulphurous acid and sulphites cannot be regarded as harmless as they may cause dyspeptic symptoms, investigations have shown that in the amounts employed in foods they have no specific toxic action and may be therefore regarded as the least harmful of preservatives, the greater part being converted into harmless sulphates during and after absorption.

Sulphur Dioxide is permitted in sausages in amounts not exceeding 3 grains per pound, jams 3 grains per pound, dried fruits 7 grains per pound, beer and cider 5 grains per gallon, alcoholic and non-alcoholic wines and cordials, fruit juices 3 grains per pint and fruit pulp 5 grains per pound.

Artificial Colouring Matters.—Artificial colouring matters are used extensively in the preparation of food for sale. Confectionery and sweetmeats, butter, margarine, biscuits, jams, jellies, canned peas, non-alcoholic wines, cordials and mineral waters are articles which may be coloured artificially. The colours used may be considered under three groups :—

(1) Pigments—*e.g.*, Armenian Bole and similar compounds of iron used in colouring sausages, anchovy paste, potted meat and sweets.

(2) Natural organic colours—*e.g.*, annatto, saffron, caramel, cochineal, gamboge. Some of these dyes are combined with metallic salts to form lakes.

(3) Synthetic dyes of coal tar origin of which there are a large number.

The few pigments and natural organic colours used nowadays are harmless and may be permitted for colouring food provided they conform with the standards as regards arsenic and metallic contamination. Poisonous inorganic substances are prohibited. Sweets and confectionery are often coloured yellow by compounds of barium, arsenic,

antimony, and lead; compounds of arsenic and copper are used to give a green colour, or compounds of Barium and Zinc to confer whiteness, and Prussian Blue to produce a blue colour.

Graphite is occasionally used to improve the colour of tea and pepper corns; turmeric, oxide of iron, prussian blue, and caramel are used to colour tea and coffee.

Copper sulphate is used to give an artificial green colour to peas and other vegetables like spinach, haricots, etc., which have partly lost their colour naturally, or in the process of canning. The vegetables are boiled in a solution of copper sulphate of necessary strength before canning. The copper salt penetrates into the tissues and forms a stable copper compound which imparts the necessary colour. Recent experiments have shown that the administration of copper in small doses over a large period may give rise to Cirrhosis of the liver, and Sclerosis of the pancreas. The addition of copper salts to vegetables is therefore, prohibited.

The Departmental Committee suggested that no colouring matter used for the preparation of food should contain more than $\frac{1}{100}$ gr. of arsenic per pound, or 20 parts per million of lead, copper, or zinc.

The Ministry of Health of England disallow any compounds of any of the following metals:—antimony, arsenic, cadmium, chromium, copper, mercury, lead and zinc. Amongst vegetable colouring matters gamboge is prohibited.

As regards the synthetic dyes great care has to be exerted in their choice as many are known to be of a toxic character.

It has been argued that in view of the very small quantity of the dye (about 1 part in 12000 or more) in any food no serious effects would be produced unless the toxicity was very marked, but as many of these dyes have great antiseptic properties in very weak solutions they may possibly have a deleterious effect even in such minute quantities.

The Ministry of Health have permitted the use of Picric Acid, Victoria Yellow, Manchester Yellow, Aurantia, and Aurin among the coal tar colours.

COOKING OF FOOD.

Cooking improves the appearance and flavour of food, thereby increasing its palatability.

As the effect of heat on proteins is to coagulate them at about 170°F., the digestibility of animal foods is diminished rather than increased by cooking. The digestibility is however indirectly increased by the increase in flow of the gastric juice produced by the attractiveness and flavour of cooked food. The effects on the proteins of vegetable food are exactly the same, but the digestibility of vegetable foods is increased by cooking as dry heat converts the starch into a soluble form (dextrin) and moist heat causes the starch granules to swell up and ultimately to rupture their cellulose envelopes. The fats of food are not so much affected unless the temperature is very high and the fats are decomposed with the liberation of free fatty acids.

When meat is cooked, there is concentration due to the evaporation of water, and there is loss of extractives and salts. The effect of heat and moisture on meat is to convert the connective tissues into gelatine, so that the fibres separate and the meat becomes tender.

When vegetables are cooked there is an increase in bulk due to the absorption of water, but the loss of salts is sometimes very considerable.

Great care must be taken in the choice of pots and utensils. Iron, tin, nickel and aluminium ware are the best. The glaze of enamelled ware should not contain any lead which is soluble in acid. Copper vessels must be tinned internally, on account of the possibility of organic acids dissolving the copper. Modern gas and electric stoves are convenient, and clean, and have no dust, ashes, and dirt like the coal cooking range.

BOILING.—In boiling a joint the flavoury constituents, *viz.*, extractives and salts which are readily soluble in water should be retained. This can be achieved by using as small a quantity of water as possible and secondly by plunging it first into boiling water for a few minutes whereby an impenetrable layer is formed on the surface by the rapid and complete coagulation of proteins in the fibres of the meat, and the remainder of the cooking should be continued at a temperature below 170° F.

In making a good soup the meat is placed in cold water and gradually heated so that the extractives pass into the water.

ROASTING.—The heat is conveyed by direct radiation instead of through water. The joint should be exposed to a high temperature at the outset to coagulate the proteids on the surface and thereby effect a sealing of the surface to prevent the loss of extractives and salts. The temperature is then lowered and the roasting continued at 180° to 200° F. If properly performed not only can the escape of natural flavour of meat be prevented but certain changes are produced in the extractives analogous to the change of sugar to caramal.

STEWING.—In stewing meat is placed in cold water and gradually heated to 180° F, but if heated to a higher temperature the meat becomes tough and unpalatable. As the gravy is eaten with the meat there is no loss of extractives and salts.

FRYING.—In frying fish is placed for a few minutes in oil or fat (*e.g.* Olive oil, sweet oil, etc.), heated to a very high temperature about 350° F. The sudden exposure to heat coagulates the proteins on the surface with slight charring, and the flavour and juices are thereby retained. The high temperature almost instantaneously cooks the fish through its whole thickness.

FOOD POISONING.

Food poisoning is an acute illness caused by the consumption of unwholesome food. It may be due to :—

(1) Food infection—The contamination of food with bacteria of the Salmonella group, *e.g.*, Bacillus Enteritidis (Gaertner).

(2) Food toxaemia—the contamination of food with preformed toxins of Bacilli, *e.g.*, B. Botulinus.

(3) Natural toxic properties of food.

(4) Metallic contamination, *e.g.*, with tin, arsenic, lead.

(5) Harmful colouring matter and preservatives.

(6) Fermentation and putrefaction.

Food Infection.—Savage and White in a study of food infection due to organisms of the Salmonella group have recognised the following types :—B. Enteritidis (Gaertner) B. Aertrycke, B. Suipestifer, and certain varieties designated "Derby" "Stanley" and "Newport".

Such cases were formerly misnamed ptomaine poisoning on the belief that the symptoms were caused by ptomaines produced from bacterial decomposition of the proteins in food. Neither B. Proteus nor B. Vulgaris, the microbes of putrefaction, nor B. Coli are the causative organisms of food poisoning. The great majority of the out-breaks are due to the consumption of tinned meat and fish, but fresh meat, milk and milk-products, fresh and preserved food and vegetables, etc. have also been responsible. The flesh of cattle and hogs suffering from septicaemia, septic pyaemia, puerperal fever, or a local suppuration due to the bacteria of the Salmonella group is usually the source of infection.

Healthy carcasses in a slaughter house may be infected through the hands of butchers who have handled infected meat or through the knife or other instruments. Such infected meat usually presents no alteration in appearance, taste or smell which would enable one to consider it as dan-

gerous. Cooked or uncooked meat may also be infected by rat, or mice as they may be carriers of B. Suipestifer and Enteriditis or through contact with bacterial viruses like B. Typhi Murium used against rats.

The flesh of animals suffering from septic or pyaemic lesions either general or local should, therefore, be condemned. The condition may be detected ante-mortem or post-mortem. Great care must be taken for the disinfection of hands by the butchers and the sterilisation of instruments to prevent the infection spreading from one carcass to another. Every care must be taken to prevent contamination from rats and mice.

Incubation period is usually six to twelve hours but may vary from half an hour to two days or more depending on whether the toxins were preformed in the meat or formed in the body after consumption of the food. The symptoms are those of a severe gastro-intestinal irritation characterised by nausea, vomiting, diarrhœa and severe griping pains and accompanied by acute nervous prostration, restlessness, cramps, rigors and collapse. Skin eruptions and albuminuria may be present. The symptoms may vary in severity according to the virulence of the strain of bacilli, dose and the susceptibility of the patient.

The post-mortem appearances are slight as compared with the severity of the symptoms. The mucous membrane of the gastro-intestinal tract may be swollen and congested and show hæmorrhages.

The infectivity rate is high, but the case mortality is low being about one per cent. when due to B. Aertrycke due to the low invasive form of the latter, but high in the case of B. Gaertner. Meat poisoning is common in summer, as the higher temperature favours the multiplication of the bacilli and the formation of the toxins. Those who eat the food soon after preparation may be less affected than those who consume it after a long interval as it will afford time in the latter case for the formation of toxins.

Food Toxæmia—Botulism (sausage poisoning).—Botulism is a specific toxæmia due to the contamination of food with B. Botulinus and its toxins. The bacillus itself is a harmless saprophyte but it grows in a large variety of food-stuffs, both animal and vegetable, and produces a toxin in the food. The toxin is very poisonous, 0.000001 c.c. being sufficient to kill a guinea pig of 250 grammes weight in three or four days. Not much reliance can be placed upon odour and appearance to suspect the presence of the toxins in food. This form of poisoning has been caused by eating sausages, potted meat, tinned fish, preserved beans and fruit. The period of incubation may vary from a few hours to three days, the shorter the incubation period the greater the severity of the poisoning. When the incubation period is short there is usually no acute gastro-intestinal irritation as in the case of the poisoning with B. Enteritidis. The symptoms are chiefly those of intense nervous prostration, disturbances of vision (Ptosis, diplopia, nystagamus, dimness of vision) dizziness, difficulty in swallowing and breathing. There is no fever or pain or any sensory disturbances, and the mind is clear. The case mortality is high (sometimes even 100 per cent.).

An anti-toxin prepared by injecting increasing units of the toxins into horses is effective both as a prophylactic and as a curative.

Naturally Toxic Food.—Some fish normally contain a poisonous toxin injurious to men. Certain shell-fish cause violent gastro-intestinal irritation and urticaria. Mussels, crabs, shrimps, salmon, and sardines have all given rise to poisoning symptoms. Certain Fungi (Ammanita phalloides) and Lactaria torminosa are poisonous. Muscarin is believed to be the toxin of mushroom poisoning. Potatoes may contain a large amount of poisonous substance (solanin) due to the decomposition through a Proteus bacillus. Milk, cream and cheese may contain rarely Tyrotoxicon, due to fermentation, which may give rise to symptoms akin to

atropine poisoning. Ergotism is disease produced by the prolonged use of bread of rye and other grain contaminated with ergot a parasitic fungus, Claviceps purpurea, of grain. Lathyrism or vetch poisoning is due to eating bread from meal containing the seeds of Lathyrus sativus used as a partial substitute of wheat. The nature of the poison is supposed to be toxalbumose like ricin and abrin. Certain plant foods, *e.g.*, tomatoes, strawberries etc. may cause allergic symptoms like urticaria in susceptible persons.

METALLIC POISONING.—Poisoning symptoms may be traced to the presence of tin, lead, copper or arsenic in food. Arsenic has been found in beer, sweets, sugar, wines or the enamels of utensils used for cooking. Apples have been sprayed with arsenic compounds .to protect them from nisects. Copper sulphate has been used for colouring vegetables green, and tin and lead have been found in preserved foods.

In investigating a case of food poisoning accurate and detailed notes must be taken of the history and symptoms of all cases. Every article of food consumed must be noted down and by a process of exclusion, suspicion laid on certain foods taken in common by the persons attacked. All available material of suspected food and vomit, excreta, etc. of patients, and when post-mortem had been held, pieces of the internal organs must be preserved for chemical and bacteriological examination. Risks of contamination in preparation, storage and transport must be inquired into. Feeding experiments on lower animals, and agglutination tests with the patient's serum and cultures of organisms isolated and suspected will have to be done.

FERMENTATION AND PUTREFACTION.—Decomposition may arise through fermentation or putrefaction. Fermentation is the breaking down of carbohydrates with the formation of lactic, acetic, butyric acids, alcohol and carbon dioxide. Putrefaction is the decomposition of organic matter, generally protein, due to the bacterial action. By

the action of certain aerobic and anaerobic bacteria they are decomposed, the end products of putrefaction being Ammonia, Carbon Dioxide, nitrates, Sulphuretted Hydrogen etc. which are not poisonous. It is the intermediate products of putrefaction known as Ptomaines which may be poisonous, *e.g.*, methylamin, sepsin, putrescin, muscarin, neurin, etc. Some ptomaines are poisonous being physiologically active while others are inert.

The majority only contain C, H, and N and are amino-substitute compounds. Those having oxygen are more active. None of them is actually poisonous, when taken by the mouth, and even the active ones do not produce nausea, vomiting, colic and diarrhœa.

In putrefaction the flesh softens and tears readily offering less resistence in some parts than in others. The colour, changes gradually and ultimately becomes greenish and a characteristic odour is emitted.

The term ptomaine poisoning is hardly ever used nowadays as most cases of poisoning believed to be due to ptomaines are now found to be due to bacterial infection.

FOOD ADULTERATION.

Food adulteration is extensively carried on in India. In order to prevent the adulteration and sale of such articles in Bombay, the Prevention of Adulteration Act has been in force since 1925, and similar acts have been passed all over India.

Food may be adulterated fraudulently, or it may be technically required to treat it in a particular manner to prepare it as an article of commerce in a state fit for carriage or consumption.

Food may be adulterated by :—

(1) The removal of nutritive or essential constituents.

(2) The addition of non-injurious and cheaper substances so as to increase its bulk.

(3) Substitution of cheaper articles.

(4) Addition of injurious substances to conceal inferiority.

(5) Addition of injurious substances to preserve them.

(6) The sale of decomposed vegetable or animal food.

(7) Misbranding.

(1) *The abstraction of nutritious substances.*—Milk from which cream is abstracted is sold as whole milk by fraudulent dealers. Milk from Gujerat with only 0.1 per cent. of fat is clandestinely imported into Bombay. There is no objection to abstraction of cream so long as the milk satisfies the legal standard. Skimmed milk may be sold provided a label clearly announces the fact. The mixing of cloves and spices with those from which the essential oils have been extracted, is also carried on. Used tea leaves are sometimes dried, rolled and sold again. Such spent or exhausted leaves are " faced " so as to resemble genuine tea.

(2) *Addition.*—The addition of cheaper food-stuffs so as to increase the bulk, weight, or measure, thereby affecting its quality or strength is found. The addition of water to milk is the common example. Other examples are :—Honey may contain glucose; coffee may be adulterated with chicory, caramel, and saccharine extracts; flour, or tumeric may be added to mustard; hydrogenated vegetable oils, or animal fats or fish oils may be mixed with ghee or butter; talc may be added to flour and silicates to confectionery.

(3) *Substitution.*—The sale of any article of food which is not of the nature, substance and quality which it purports to be, is an offence. The sale of vegetable products as ghee or butter, of cotton seed oil as olive oil, or use of saccharin instead of sugar are examples.

(4) *The addition of colouring matter.*—Food-stuffs may be artificially mixed, coloured, powdered, coated or stained, with the intention of concealing danger or inferiority. The dyes usually used are (1) mineral, (2) vegetable, (3) coal tar

dyes. Copper sulphate is used to give a green colour to peas, iron oxide, a red colour to meat, and potash nitrate, a bright red to canned meat. Flour may be bleached by the nitrogen process. Amongst vegetable dyes annatto is used for butter, logwood for wines, and turmeric in mustard. The coal tar dyes on account of the brilliant colour and cheapness are used for confectionery, jellies, meats, flavoury extracts, etc.

(5) *Addition of Preservatives.*—Formalin, boric acid, sulphates, salicylates, etc. are added to food-stuffs to prevent food from undergoing decomposition. With the modern methods of sterilization and refrigeration, the addition of preservatives is unnecessary and is prohibited except in few exceptional cases.

(6) *Vegetable and animal food sold in a state of decomposition or filthy state.*—Examples: Oysters contaminated with sewage, rotten eggs, animals who have died from disease or accident, decomposed fruits.

(7) *Misbranding.*—Includes mislabelling, imitation, substitution, etc., whereby the consumer is deceived and purchases at a higher price an article of inferior quality.

Under the Prevention of Food Adulteration Act, rules are made for the labelling of margarine, and vegetable products, or Vanaspati; and condensed skimmed milk, and also for declaring the presence of Preservatives.

The Adulteration of foods Act provides for the prevention :—

(1) of mixing, colouring, staining, or powdering any article of food for sale with any matter injurious to health.

(2) of the sale of an article of food which is not of the nature, substance and quality it purports to be.

Exceptions—

(*a*) When any ingredient not injurious to health has been added for the production and preparation

of the food as an article of commerce in a state fit for carriage or consumption and not fraudulently to increase the bulk or conceal the inferior quality.

(b) A label indicates that some ingredient not injurious to health has been added or some matter abstracted.

Any person empowered by the Commissioner purchasing an article or sample of food with the intention of sending such an article for analysis shall after the purchase shall have been completed, forthwith notify to the seller or his agent selling the article or the sample his intention to have such article or sample analysed by the Public Analyst; and shall offer to divide the article or sample into three parts to be there and then divided and each part to be marked and sealed and fastened in such manner as its nature permits, and shall if required to do so, proceed accordingly and shall deliver one of the parts to the seller or his agent.

If the seller or his agent do not accept the offer of the purchaser to divide the article or sample purchased in his presence, the Public Analyst receiving the article or sample shall divide such article or sample into two parts and shall seal or fasten up one of those parts and shall cause it to be delivered, either upon receipt of the article or sample or when he supplies his certificate, to the purchaser, who shall retain such part for production in case proceedings under this Act in respect of such article or sample should afterwards be taken.

Any vendor refusing to sell such an article is liable to prosecution.

In the *Rules* framed under the Prevention of Adulteration Act, 1925, the following standards are laid down for certain articles of food.

Deficiency in normal constituents and addition of extraneous matter.—(*i*) The following articles of food when constituted as shown hereunder shall be presumed to be not of the nature, substance, or quality they purport to be :—

(*a*) Cow's milk which contains less than 3.5 per cent. of milk fat or less than 8.5 per cent. of milk solids other than milk fat;

(*b*) Buffalo's milk which contains less than 6 per cent. of milk fat or less than 9 per cent. of milk solids other than milk fat;

(*c*) Skimmed milk which contains less than 8.7 per cent. of milk solids other than milk fat;

(*d*) Butter milk which contains less than 8 per cent. of milk solids other than milk fat;

(*e*) Butter which contains more than 16 per cent. of water;

(*f*) Ghee which contains more than 1 per cent. of water.

(*g*) Wheat flour which contains Alum or more than 2 per cent. of ash or less than 8 per cent. of gluten;

(*h*) Tea which contains leaves which have not the structure of the leaves of the genus Camellia.

(*ii*) The following article of food when failing on analysis to yield the results referred to hereunder shall be presumed to be not of the nature, substance or quality it purports to be :—

Tea which dried to a constant weight at 100°C. does not yield from 4 to 8 per cent. of total ash, the proportion of total ash soluble in boiling water being not less than 40 per cent. and which on boiling in the proportion of one part of tea to 100 parts by weight of distilled water for one hour does not yield 30 per cent. or more of extract.

MILK.

Milk is the natural secretion of the adult female mammal intended for the use of her newly-born offspring, and contains all the constituents needed for the entire nutriment of

a young growing animal. The constituents of milk, *viz.* fats, sugar and proteins, are all formed from the protoplasmic contents of the cells of the epithelium, lining the ramifications of the ducts of the mammary gland through the vital activity of the cells. Milk is one of the most important food not only for the young baby but even for adults. It is comparatively cheap, palatable, and easily digestible. It contains all the necessary constituents of a balanced diet and being rich in vitamins serves to protect from deficiency diseases. People who drink milk, develop both physically and intellectually far more than those who live only on vegetable food. For adults, however, it has to be combined with a vegetable or animal diet as it has much water, little roughage, little iron, and lacks in vitamin E.

CONSTITUENTS OF MILK.

Milk is a yellowish white opaque fluid, with a specific gravity of 1027 to 1035 and an amphoteric reaction. It is complex in composition and is made up of milk plasma in which fat globules are suspended. It contains water, proteins, fats, carbohydrates, mineral salts, vitamins, extractives, enzymes, antibodies, cells, gases and other substances. Microscopically fat globules, cells, bacteria, debris, etc., are to be seen. The milk of various mammals contains essentially the same constituents but in different proportions.

The average percentage composition in different mammals is given below :—

——	*English Cow.*	*Indian Cow.*	*Indian Buffalo.*	*Human.*	*Mare.*	*Goat.*
Water	87.40	86.10	81.6	87.68	88.40	85.60
Total Solids ..	12.60	13.90	19.4	12.32	11.60	14.40
Sugar	4.75	4.65	4.52	6.40	5.87	4.30
Fat	3.65	4.85	8.60	3.40	1.76	5.00
Proteins	3.48	3.70	3.89	2.20	3.58	4.35
Mineral Salts ..	0.72	0.07	0.78	0.32	0.39	0.75

Proteins.—The proteins found in milk are caseinogen, lactalbumin, lactglobulin, and traces of fibrin and mucin. Protein in milk ranges from 2.5 to 5 per cent. and contains all the amino-acids in proper proportions to build up tissues. Caseinogen is a neutral salt of Casein and Calcium Phosphate. Caseinogen belongs to the group of nucleoalbumins, and contains Phosphorus, and coagulates with rennet in the presence of a sufficiently large amount of lime salts, a curd being formed. It is also precipitated by the addition of acid. The curd consists of casein with entangled fat, and the liquid residue (whey) contains sugar, salts, and lact-albumin of milk.

Lact-albumin varies from 0.2 to 0.8 per cent., but is more abundant in Colostrum. It contains Sulphur but no Phosphorus and is soluble in water. It coagulates on heating to 70° C but not with dilute acids. It is precipitated by a saturated solution of ammonium sulphate but not by a neutral solution of sodium chloride and magnesium sulphate.

Lactglobulin is present in traces in milk but is abundant in Colostrum. It resembles serum globulin.

Fat exists in the form of fine emulsion in milk and can be separated by allowing milk to stand, when the fat being lighter rises to the top, or by the use of centrifugal force. The size of the fat globules vary, and each globule is supposed to be enveloped in a fine albuminous membrane or stroma-like substance but this is questioned. On shaking the fat, the globules gradually coalesce and form butter. Milk fat constitutes about 3.5 to 6 per cent. of the total weight, but some milks contain even 8 to 12 per cent. of fat. The amount of fat is not constant but varies with the breed, season, food, etc. Milk fat consists of the glycerides of oleic, palmitic, and stearic acids, and also of the volatile fatty acids, *viz.*, butyric, capric, caproic and capyrilic. The fore-milk or the first portion drawn from the udder is poorest in fat, the "strippings" or the last is always the richest, whilst the middle portion contains the average percentage.

A diet rich in fat would not increase the proportion of this constituent in the milk. In a fatty diet, all fats taken up by the lacteals of the intestines are consumed in the production of heat and energy, all fats not so taken up are discharged with the excreta. Metabolism in the organism is stimulated to greater activity by nitrogenous foods, it is retarded by fatty foods, and all the fats obtained in milk are derived from albuminoids and not from fats and carbo-hydrates, the latter being consumed in the production of heat and energy. It is found in practice and by experiment that a cow at grass yields in her milk more fat than is ingested with her food. The sugar too is formed by the same protoplasm and not from the carbo-hydrates taken in with food.

Lactose or milk sugar is a carbohydrate and is always in solution. Milk sugar is split up into dextrose and galactose by the action of an enzyme "lactase" existing in yeast. The dextrose is further changed into lactic acid by the lactic acid bacilli, which cause the souring of milk. After this is fully established the casein begins to decompose and protein ptomanies of a poisonous nature are formed. Human milk contains 6.4 per cent. of lactose and cow's milk 4.75 per cent.

Mineral Salts.—The principal mineral salts are calcium phosphate, magnesium phosphate, sodium and potassium chlorides, and a little of iron. Milk is a good source of calcium in dietary because of its large quantity and its assimilable form. Children are able to take up calcium from milk more readily than from vegetables. The mineral salts amount to 0.7 per cent.

Vitamins—Milk contains vitamins A, B, C and D. Cream is very rich in vitamin A, and the amount depends on the diet of the cow, fresh green fodder raising it to its maximum. Vitamin A is destroyed when the milk is evaporated in vacuum or by aeration methods. Vitamin A had always been regarded as growth-promoting but recent experiments suggest that it is primarily concerned in preventing

infections and only indirectly promotes growth by preventing infections.

Vitamin B consists of two factors B_1, the thermostable antineuritic, and B_2 the thermostable, Pellagra preventing (P.P.). Milk contains both these but in very small quantities which are insufficient to make good deficiency of them in other articles of diet.

Vitamin C (antiscorbutic) is present in small quantity and the amount varies with season and the diet of the cow. It is very easily destroyed by oxidation, which is accelerated by heating.

Milk is rich in vitamin D (antirachitic) and the amount can be greatly increased by the irradiation of milk by ultra-violet light.

Ferments.—Milk contains a large number of enzymes or ferments, some of which are normal constituents and others the results of bacterial activity.

The enzymes present are galactase, lactokinase lipase, perioxidase, catalase, reductase, and amylase. Galactase does not produce any change in the milk in the short period between production and consumption but it probably helps in the digestion of milk. Lactokinase assists the pancreatic juice in the digestion of a portion. Catalase and reductase and others are probably of bacterial origin.

Extractives present in milk are lecithin, cholesterin, etc.

Water in milk varies from 85 to 88 per cent.

The gases dissolved in milk are oxygen, nitrogen, and carbon-dioxide. Milk has got a great avidity for absorbing gases and vapours, organic and inorganic from the air.

Milk is a perfect food for the suckling of the same species, thus the human baby thrives better on human milk. Two-thirds of the protein in human milk is soluble lactalbumin and one-third caesinogen, whilst in cow's, one tenth is lactal-

bumin and the remainder caseinogen. The mineral salts are higher, but milk sugar is much less in cow's milk. On account of the large amount of caseinogen the curds formed in the child's stomach with cow's milk are coarse and large whereas with human milk only loose flocculent mass is the result. Cow's milk will therefore disagree with infants and give rise to flatulence and diarrhœa unless it is so modified as to resemble human milk in composition. Even then as mother's milk contains specific antibodies, vitamins, and other unknown qualities which have remote effects on the nutrition of the baby, infants should always be brought upon human milk as cow's though humanized, can never be just as good.

The simplest method of humanising cow's milk is by mere dilution, *i.e.*, adding one part of cow's milk to one part of water. This approximates the proportion of protein in cow's milk to human milk but leaves the fat and sugar too low. This can be rectified by adding one ounce of ordinary centrifugalised cream and an ounce of milk sugar to every pint of the diluted milk. In order to prevent the firm clotting to which cow's milk is prone, barley water or any other mucilagenous substance may be used to dilute it. These substances act mechanically by getting between the particles of casein during coagulation and so preventing their running together and forming compact masses. Soda bicarbonate 6 grs. to an ounce of mixture or limewater in the proportion of 1 to 2 of the milk mixture may be added to partly neutralise the acid of the gastric juice so that the casein is coagulated slowly in small masses. Citrate of Soda (2 grains to every ounce of milk) increases the digestibility of casein by precipitating the excess of calcium salts and causing the casein to form less dense curds.

There are several other methods recommended for humanising milk, for instance: whey milk mixture. The whey is prepared by warming a pint of milk to blood heat, adding a tea-spoonful of rennet and straining when the

curd has set. The whey is then heated to 150° F to destroy the rennet. A weak "humanised milk" can be made by mixing 10 ounces of fresh milk with 10 of whey and adding $\frac{1}{2}$ ounce of milk sugar.

Asses' and mares' milk resembles human milk more closely, the curds being loose and flocculent and easily digestible. Goat's milk contains too much fat and protein but is a good substitute for cow's milk for children, the curds formed in the stomach being easily digestible.

Colostrum is the fluid secreted by the mammary gland for a few days after birth till lactation becomes established. It is very rich in globulin, and differs from milk in composition, appearance and function. In cows it helps to protect the calf against bacterial infections till it has acquired a natural immunity. It is not essential for infants as antibodies pass more easily through the human placenta into the fœtal cord.

CHEMICAL EXAMINATION OF MILK IN INDIA.

The composition of milk in India differs from that in Europe and America in many respects. In India the milk of the buffalo is very largely consumed, even more so than that of the cow. The reasons for this probably are: (1) the yield of milk per buffalo is greater than that of the cow, hence commercially, other things being equal, it is more advantageous to the supplier; (2) buffalo milk is richer in total solids and fat; hence a larger return in cream and butter, etc. The average composition of cow's and buffalo's milk is as follows :—

	Cows.	*Buffaloes.*
Specific Gravity	1030.87	1030.8
Total solids	13.9 %	18.4 %
Fat	4.85 %	8.6 %
Solids not fat	9.04 %	9.8 %

The fat in Indian cows may rise to 7 to 8 per cent. and in buffaloes to 11 or 12 per cent.

For the routine examination of milk the specific gravity and fat need only be determined, and from these the solids not fat by Richmond's Rule. From the solids not fat the percentage of adulteration is calculated.

Milk standards.—In Bombay the legal standard laid down for cow's milk is 3.5 per cent. fat and 8.5 per cent. solids not fat and for buffaloes milk 6 per cent. fat and 9 per cent. solids not fat. Skimmed milk must not contain less than 8.7 per cent. of milk solids other than milk fat, and butter milk must not contain less than 8 per cent. of milk solids other than milk fat.

The following Table shows the changes in the composition of milk when it is adulterated with water or is skimmed:—

	Watered Milk.	Skimmed Milk.
Specific Gravity	Decreased.	Increased.
Fat per cent.	,,	Decreased.
Total Solids per cent.	,,	,,
Solids Not Fat per cent.	,,	Unchanged.
Proportion of Fat per cent. to Solids Not Fat per cent.	Unchanged.	Decreased.

There are numerous factors which influence the physical characters, chemical composition and bacterial contents of the milk. Dr. Joshi has classified them as follows :—

(1) *Climatic*—Seasonal and daily variations, effects of weather.

(2) Conditions relating to the Milch cattle.

(*a*) Heredity and breed, (*b*) food, (*c*) housing and tendering, (*d*) age, (*e*) period of lactation, (*f*) diseases of milch cattle.

(3) Conditions ascribed to the Gowlis and milk dealers.

(a) Customs and habits, *e.g.*, method of milking.

(b) Communicable diseases.

(4) *Miscellaneous Factors*—Collection, storage, transportation, distribution, etc.

Temperature and humidity have very slight influence so long as green fodder is available. There is usually a difference in the relative composition of morning and evening milk of cows and buffaloes, the evening milk being always richer in fat than that of the morning. In Bombay there is usually a slight lowering in the percentage of total solids in the rainy season due to the green and succulent fodder. Breed has a great influence on the quality and quantity of milk, the Surti buffaloes, and the Sindhi and Gir cows yielding more fat. The Delhi and Jaffrabadi buffaloes produce the largest quantity of milk. As regards food, cattle fed on food rich in proteins will yield milk of a superior quality, specially as regards fat. A highly nitrogenous food, increases the fatty constituents, and oily food increases the quantity but renders it watery, hence the practice of the Gowli to feed his cattle on the cotton seed. Animals fed on green and succulent fodder yield milk poor in total solids but the quantity is increased.

The best age for Indian cattle for the produce of milk is 5 to 8 years. The lactation period is about 300 days. From the time of calving to the time of "drying up" as the quantity of milk gradually diminishes, the richness increases, the total solids specially the fat increasing with the advance of the lactation period.

ADULTERATION OF MILK.

Milk may be adulterated by :—

(1) *Skimming.*—A part or whole of the cream, as it fetches a higher price, may be removed and the remaining fluid sold as whole milk. Since Indian Buffaloes give on

an average 8 to 9 per cent. of fat, and the legal standard is 6 per cent., vendors usually abstract a part of the cream and yet satisfy the standard. The specific gravity of skimmed milk will rise to about 1036 and the percentage of fat may be reduced to as low as 0.1 per cent. There is no objection to the sale of skimmed milk so long as a label declares the nature of the milk. Milk at present imported into Bombay from Guzerat contains only 0.1 per cent. of fat, and is treated with Boric acid or Boric acid and Formalin to preserve it during the long journey and sold as pure milk.

(2) *Watering.*—The addition of water to increase the quantity is a common practice with Gowlis in India. The milk in addition to being diluted and lowered thereby in nutritive value may be infected with pathogenic germs introduced through the impure watêr added. The addition of water will lower the specific gravity according to the amount of water added and raise the freezing point. In actual practice it is estimated in the laboratory by the diminution in the percentage of the non-fatty solids. Out of 27,292 samples of milk examined in the Municipal Laboratory during the last five years 29 per cent. were found adulterated with water.

(3) *Thickening agents* like chalk, starch, gelatine, sugar, etc. are added to give viscosity to watered milk. Colouring matter *e.g.*, annato is occasionally added to conceal skimming or watering, or to make the milk look rich; alkalies like Soda Bicarb are added to reduce acidity, delay curdling or improve the taste; sweet substances *e.g.*, Saccharin and sugar are added to raise the specific gravity and thus disguise watering or to mask the taste of souring.

(4) *Chemical Preservatives.*—Chemical preservatives are often added to milk with a view to preventing bacterial growth or keeping it in an apparently unaltered condition for a prolonged period. This is chiefly done for commercial purposes. The chemicals most frequently used are boric

acid and formaldehyde. Others, however, are sometimes added, such as benzoic acid, salicylic acid, soda bicarbonate and hydrogen peroxide. It has been found, however, that these preservatives are added in variable quantities and in almost all cases more in amount than actually required to preserve the milk for 24 hours. All such preservatives are positively harmful and dangerous to health, especially to invalids, children and infants. It has been found by experience that chemical preservatives are totally unnecessary for keeping milk for 24 hours, and the knowledge that these preserve milk, serves the milk supplier's purpose of selling preserved stale milk, which may contain pathogenic bacteria and toxins, and forms also an incentive for the supplier to collect milk under conditions of neglect and dirt.

In England the addition of Chemical preservatives to milk is prohibited, nor may colouring agents be added. In Bombay, chemical preservatives and thickening agents cannot be added to milk.

BACTERIA IN MILK.

Milk as secreted by a healthy animal is a sterile fluid. It may be contaminated in various ways from the udder to the consumer and usually contains more bacteria than any other food. The sources through which bacteria may gain access to milk may be grouped as follows :—

(*a*) Intramammary
(*b*) Introduced during the milching process
(*c*) From milk utensils
(*d*) By contamination during transit.

Bacteria may enter the lactiferous ducts from outside as there is no special obstacle to prevent their entry, the only one being the sphincter muscle at the lower end of the teat. The "fore milk" contains most of the bacteria, but the latter milk or "strippings" least. The most frequent bacteria found are the Streptococci, Staphylococci and

Pseudo-diptheritic bacilli. The number of bacteria in milk increases with the handling and exposure. All these gain access to the milk cistern, through the milk column in the teat canal in the udder and also to the final ramification of ducts from outside through the teat orifies. Bacteria introduced during the milk collection may be (1) from the hair, udder or teat of the animal; (2) from dust of the milk-shed or clothes of the milker, or from the dirt of the hands of the milker. As the hind quarters and udders of the animal are laden with dry or wet dung, some of it. of necessity finds its way into the milk pail. The air and dust of the shed are full of bacteria, which may contaminate the collected milk either during the process or when stored, as the pails are almost always uncovered. Milk vessels when improperly cleaned form a grave source of contamination of milk. The water used for cleaning these vessels must be from a pure source. During transit, milk may be contaminated if not conveyed with tightly fitting covers. It can be imagined how badly milk may be contaminated in India by the Gowli who covers the milk, to prevent splashing, with rings of hay, straw or green grass which he finds handiest; or again when exposed for sale in open vessels in the streets, it may receive dust laden with particles of dried street and domestic refuse; by flies which may have fed on excreta and other decomposing matter.

To keep the bacterial count low it is necessary to chill the milk and keep it at 40°F. The Bacteria in milk are not equally distributed through the fluid but are more abundant in the cream. The Streptococci found in milk may possibly be derived from local pathological lesions such as mastitis or ulceration in the udder. The presence of streptococci may also indicate manurial pollution, and they are harmful to infants in as much as they cause Gastro-Enteritis and infantile Diarrhœa. Staphylococci are almost always abundantly present in milk, but their presence does not indicate any pathological significance. Bacillus Coli and allied forms

indicate either manurial or *fæcal* pollution and such contamination may be obviated by observing scrupulous cleanliness during milking. B. Coli and Coli-like bacilli are lactose fermenting bacteria of intestinal origin and their presence in milk is largely proportional to the amount of cleanliness exercised during milking.

Bacillus Enteridis Sporogenes shows that the pollution is manurial or fæcal, as the spores of the same occur abundantly in fæces and dung.

Bacillus Butyricus resembles the Enteridis Sporogenes. They are both anærobic and both seem not harmful to man; B. Enteridis, however, is of importance as it indicates pollution from dung. Besides these, B. Subtilis, B. Mycoides, B. Mesentericus Vulgatus are also present. These are ærobic but non-pathogenic. They indicate contamination from outside, probably hay, and have a decomposing effect on milk. They are also heat-resistent and therefore constitute most of the bacilli left in imperfectly sterilized milk.

Pathogenic bacteria usually enter the milk from human sources. Diphtheria, scarlet fever, typhoid, cholera etc. are always introduced into the milk through man. The steptococci of septic sore throat may be implanted on the udder of a cow from a human case, where it will grow and multiply and infect the milk.

Malta fever, milk sickness, and foot and mouth diseases are conveyed through the milk of affected cattle; and also Bovine Tuberculosis if the udders of the cow are affected.

BACTERIOLOGICAL EXAMINATION OF MILK.

This is for the purpose of finding out contamination with microbes, dirt, cowdung, etc.

Microbes per c.c.—The number of bacteria in milk is the best single index we have of its general sanitary character. (Rosenau.)

The highest count Dr. Joshi obtained in some of the Bombay milks was 118,400,000 microbes per c.c. and the lowest 250,000 microbes per c.c. The above figures are only approximate for, as Savage says: "There are no nutrient media and no known conditions of growth which will allow all the bacteria in milk to develop." Without entering into a detailed discussion, it may be said that the count has a relative value when the samples are examined under identical conditions. The number of microbes varies a great deal, depending upon— (1) conditions of collection and transportation of milk; (2) time elapsing between the collection and the examination and (3) temperature. The figures show a much higher count in April and May, when the heat is intense in Western India, than in July and August, when it is cooler on account of the rains.

A few cows and buffaloes were brought to the Municipal Laboratory and several samples taken under aseptic precautions and examined immediately. The average of several samples was found to be 386 microbes per c.c. This shows the value of collecting milk with proper care.

There are many difficulties in the way of adopting bacterial standards for legal purposes. A working standard, however, would be very useful for administrative purposes. Legal bacterial standards exist abroad, particularly in American cities. Boston, for instance, has a legal standard of 500,000 bacteria per c.c. Research in other parts of India is suggested. In the meantime, the following tentative standard for Bombay City has been suggested by Dr. Joshi:—

1. *Microbes per c.c.*—The total number of microbes per c.c. should not exceed two millions during the cold weather (November to March) and five millions during the hot and rainy season (April to October).
2. *Lactose Fermenters.*—These should be absent in at least 1 c.c. of the sample, if it is taken with strict sanitary precautions.

(*a*) *During the cold season*—(November to March), the sample is of—

Pure Milk	if lactose	fermenters	are absent in	1 c.c.
Good	,,	,,	,,	0.1 ,,
Fair	,,	,,	,,	0.01 ,,
Unsatisfactory	,,	,,	present	0.01 ,,
Bad	,,	,,	,,	0.001 ,,
Contaminated	,,	,,	,,	0.0001 ,,
Highly contaminated		,,	,,	0.00001 ,, and less.

(*b*) During the hot weather and monsoon (April to October) the sample is of—

Pure Milk,	if lactose	fermenters	are absent in	0.1 c.c.
Good	,,	,,	,,	0.01 ,,
Fair	,,	,,	,,	0.001 ,,
Unsatisfactory	,,	,,	present	0.001 ,,
Bad	,,	,,	,,	0.0001 ,,
Contaminated	,,	,,	,,	0.00001 ,,
Highly contaminated		,,	,,	0.000001 ,, and less.

3. Microscopic examination of the centrifugalised sediment should show only a few leucocytes and perhaps a few cocci and bacilli, but Pus cells and (pathogenic) Streptococci should be absent. There should be no leucocytosis, especially of the poly-morpho-nuclear variety.

4. Pathogenic microbes, *e.g.*, Tubercle Bacilli, Cholera Vibrio, B. Typhosus, etc., must be *always absent.*

Lactose Fermenters in Milk.—About a 100 samples were examined in the Bombay Municipal Laboratory. In most of the samples, Lactose Fermenters were found to be present in 0.000001 c.c. and more of milk, which would indicate much pollution.

In the samples collected under proper precautions Lactose Fermenters were entirely absent.

DISEASES CONVEYED THROUGH MILK.

Milk being the most suitable medium for the growth and the development of fungi and bacteria, many infectious diseases may be conveyed through it to man. The chief sources of infection are dirt and water. Dirt may enter either before or after milking, and water by the washing of pails, or by the wilful addition of it for adulteration of milk. The infection may be conveyed directly or indirectly from human sources in the farm, in the dairy, during transportation or at the house. Diseases thus conveyed by milk are Typhoid and Paratyphoid Fevers. Tuberculosis, Diphtheria, Septic sore-throat, Scarlet Fever, Cholera and gastro-intestinal troubles. Sometimes milk becomes infected as the result of the disease of the cattle as in Bovine Tuberculosis, Malta fever, Foot and Mouth disease, Garget, etc.

Typhoid Fever.—The chief source of Typhoid Bacilli in milk is the washing of the pails and the adulteration of the milk with water which has been polluted with the excreta of Enteric patients. A typhoid carrier, a convalescent of ambulant case, or flies may also infect the milk. There is no evidence of the disease being directly conveyed through the cow. The taste, colour and physical characters of milk will be unchanged and bacteriological examination for the detection of the bacillus is difficult. A large number of milk epidemics have been traced to Typhoid Fever.

Tuberculosis.—Apart from the fact that milk may be contaminated with Tubercle through a human carrier, or flies which have settled on tubercular sputum, milk is largely responsible for conveying in Europe and America bovine *Tuberculosis to man, specially to infants and children.* The milk may be contaminated either directly as the result of tuberculosis of the udder or indirectly through the excreta, the bacilli being coughed up and swallowed and passed in the excreta. Twenty-five per cent. of the stall fed dairy cattle in England are subject to this disease, and there exist

strict regulations enforcing notification of the disease in cattle. In order to eradicate Bovine Tuberculosis, the cow should be stabled in open air sheds, and tested with tuberculin every six months to weed out the infected animals. Tuberculosis is, however, rarely conveyed by milk in India. Dr. Joshi reported that of a total of 741 samples of milk examined by him acid fast bacilli were detected in 48 giving 6.47 per cent. but in no single case were genuine Tubercle Bacilli found by animal experiments.

Dr. Soparkar examined material from 111 cases of surgical Tuberculosis and found a bovine type in only one case. He concludes from this that bovine tuberculosis forms a negligible part in the causation of surgical tuberculosis in the western Presidency of India which appears to be in conformity with the infrequency of tuberculosis in cattle on this side. In northern India however he examined material from the carcases at the slaughter houses at Ferozepore and Lahore and found 19.4 per cent. of cows, 23.4 per cent. of Buffaloes, and 31.6 per cent. bullocks examined to be suffering from tuberculosis. These figures he says, approximate those in European countries and would increase the chances of infection of human beings with bacillus of bovine origin. The control and eradication of the disease among the cattle in northern India therefore calls for serious consideration.

Scarlet Fever.—Has been traced to milk infected by persons who have attended on a case or who have themselves suffered from a very mild form of disease. There is suspicion that cows may also suffer from streptococcal infection resembling scarlet fever.

Diphtheria.—The infection of milk with diphtheria is of human origin, either from an actual case or a carrier. Cows do not suffer from a disease akin to diphtheria but infection of the udder with Streptococcus Epidemicus may be responsible for cases of septic sore throat.

Cholera.—Milk is responsible for gastro-intestinal troubles some of which are specific. Cholera bacilli may enter the milk through water, flies or a human carrier. Epidemics of Cholera have been traced to milk in India. The human carrier may be one who has suffered from a mild unrecognised type of the disease, or a contact who has attended on a patient, or a chronic carrier who has recovered from the disease and passes cholera bacilli in his stools periodically for an indefinite period.

Diarrhœa and Dysentery.—Is very common among children fed on cow's and buffalo's milk specially during summer. B. Enteritidis may find its way into milk and cause an acute infection. Milk which has undergone lactic acid fermentation may cause diarrhœa and sickness in children. Fungi and Moulds (*e.g.* Penicillium, Aspergillus, Mucor) and milk containing pus and fluids from inflamed udders may cause gastric irritation. Oidium Albicans in milk will cause Thrush.

Malta Fever.—Infection is transmitted from goats to men through raw milk containing B. Mellitensis.

Foot and Mouth disease is caused by a filterable virus and is presumbly a disease of cattle and secondly of man, and is conveyed to man by milk. The cows suffer from fever for seven or eight days and get an eruption of vesicles on the mucous membrane of the mouth, udder, etc., and milk gets infected through the serum of the vesicles. In man the symptoms are mild and seldom fatal and characterised by fever, vesicles on the throat and lips, salivation and glandular enlargement. The disease may be conveyed by raw milk, and also butter, whey and cheese.

Milk Sickness.—Endemic in America, it is described as an acute non-febrile disease in man characterised by great depression, persistent vomiting and high mortality and is due to the ingestion of milk of animals suffering from a disease known as "trembles."

Under certain conditions milk may acquire poisonous properties *e.g.* metallic poisoning from vessels, elimination of certain drugs taken by the mother, toxic substances produced by certain bacteria and certain poisonous weeds eaten by cattle.

It is a well known fact that the infantile mortality in India is large as compared with European countries. The causes are numerous and complex but bad milk is one of the chief causes.

Milk borne Epidemics.—All outbreaks of infectious diseases due to milk are sudden and explosive, of short duration, and come to an abrupt and equally sudden termination. The characters of the epidemic will depend on the amount of infection, and the number of persons who drank the milk. The duration will vary with the incubation period and the length of time the milk is infected. As a rule the incubation period is short, the attack mild, and the mortality rate low. Only a few persons may be attacked or several hundreds. The infected houses will be found to be supplied with the milk of the particular vendor whose milk is at fault and only drinkers of raw milk will be affected. There will be more cases among women and children as they consume milk more largely and for a similar reason there will be a great incidence among the better class of people.

ABNORMAL MILK.

Milk may undergo fermentation or putrefaction, or have some abnormal appearance due to the action of bacteria.

Sour Milk.—The souring of milk is produced by the hydrolysis of the milk sugar by B. Acidi Lactici of Hueppi or *B.* Bulgaricus, Lactic Acid being formed which gives the milk an acid reaction.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O = \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} = \underset{\text{Lactic acid.}}{2C_3H_6O_3}$$

The Lactic Acid subsequently combines with the Calcium phosphate precipitating the Casein and curdling the milk.

Fermented Milk.—Yeast and some bacteria can produce alcoholic fermentation of milk as in the case of Koumiss prepared by the addition of cane-sugar and yeast, and Kephir by means of Kephir grains which contain yeast and various bacteria.

Slimy or Ropy Milk.—B. Lactis Viscosi renders the milk slimy or ropy due to the formation of certain mucilagenous substances through fermentation. The change may appear in 12 to 24 hours after milking and may be so pronounced that the milk can be drawn into threads or strings. Though this condition is looked upon as one of the greatest pests of cheese makers, it is of economic value in Holland and is intentionally produced for the production of special variety of cheese. The bacillus may gain admittance into a dairy through water, and can be eradicated by fumigation and disinfection.

Coloured Milk.—Some bacilli change the colour of milk. B. Cyanogenes renders it blue, B. Synxanthus yellow, B. Erythrogenes, B. Prodigiosus, and Sarcinæ, red. Red milk may also be due to the presence of blood due to some injury or acute inflammation of the udders, or cows feeding on plants containing some red pigment *e.g.* Madder root.

Bitter Milk.—Milk may have a bitter taste when freshly drawn or after standing for a few hours. Certain foods *e.g.* turnips, cabbages, and disease of the udders may produce bitter milk. It may be set up by extraneous organisms of more than one species *e.g.* Conn's Micrococcus. From an economic stand-point it is the most serious condition which the dairy bacteriologist may have to deal with as it is somewhat difficult to eradicate.

Putrid Milk.—Anærobes and some spore bearing bacilli resembling Hay Bacilli act on milk producing an alkaline

reaction and bitter taste. The milk curdless and the proteins are converted into peptones, and the milk changes into a semi-transparent liquid which is dangerous on account of the development of some toxic substances.

Dirty Milk.—All milk will contain a certain amount of dirt, but the amount will increase *pari passu* with the insanitary methods of milking, handling, transporting and storing milk. An idea of the amount of dirt can be formed by filtering a pint of milk through a little disc of absorbent cotton wool which can be dried. There are several dirt tests to estimate the amount of dirt.

CONDENSED MILK.

Condensed milk is whole, skimmed or partially skimmed milk, evaporated to one-third of its bulk. It may be unsweetened, or sweetened with the addition of cane-sugar to the extent of 40 per cent.

The condensation is effected in copper vacuum pans in which the milk is boiled under reduced pressure at a low temperature (about 50°C.) so that there is no browning or other changes incident to exposure to 100° C. and upwards. During the process gases and air are expelled and milk boils without frothing over.

Unsweetened condensed milk is prepared by placing the milk in a tank, and heating it by a hot water jacket, gradual evaporation reducing it to the required consistence. The milk is then canned and hermetically sealed and exposed to a temperature of 280°F. to ensure sterilization. Condensed milk should contain, as it is reduced to one-third its bulk, about 10 per cent. of fat, and 25 per cent of solids not fat. Unsweetened condensed milk can be used after the addition of twice its volume of water.

Dr. Coutts in a report to the local Government Board (1911) gives the following percentage chemical composition of various classes of condensed milk :—

—	Full Cream.				Machine Skimmed.	
	Sweetened.		Unsweetened.		Sweetened.	
	Lowest.	Highest.	Lowest.	Highest.	Lowest.	Highest.
Total Solids ..	68.1	83.6	29.2	38.0	59.6	79.1
Protein ..	7.3	11.4	8.0	10.0	7.6	12.3
Fat ..	8.0	13.7	8.2	11.9	0.1	6.5
Lactose ..	11.6	17.6	11.1	16.0	10.9	17.0
Ash ..	1.6	3.4	1.6	2.5	1.6	2.9
Cane-sugar ..	36.1	44.6	*Nil.*	*Nil.*	30.4	52.6

The Public Health Regulations of England require that all condensed milk shall not contain less than the following percentages of milk fat and milk solids :—

Description of condensed milk.	Percentage of fat.	Percentage of total milk solids.
Full cream, unsweetened	9.0	31.0
,, sweetened	9.0	31.0
Skimmed, unsweetened	——	20.0
,, sweetened	——	26.0

The label must also include a statement to the effect that the tin contains the equivalents of—pints of milk or skimmed milk.

In America Evaporated milk, *i.e.*, milk which is condensed to about 50 per cent. is also manufactured and sold.

No preservatives are necessary as the low proportion of water and large percentage of sugar in the sweetened varieties inhibit bacterial growth, and in the unsweetened class, the milk is sterilised at higher temperature. Bacilius

of Tuberculosis, and other pathogenic microbes are killed in condensed milks, but as certain spore-bearing bacilli, streptococci, yeasts and sarcinæ may still survive, the milk is not necessarily sterile. Bacilli may gain admittance during the process of cooling or filling up of the tins. The sweetened variety is generally used by the public.

Full cream unsweetened condensed milk is suitable for infants but the sweetened will contain an excess of sugar and may cause flatulence and diarrhœa due to fermentation. There will be a lack of antiscorbutic properties in condensed milk but this can be made up by the use of orange juice. Unsweetened skimmed milk is not recommended for infants as it will give rise to malnutrition, defective development and other evils. In England condensed and dried skimmed milk are required by the regulations to be conspicuously labelled "Unfit for Babies." The rules framed under the Food Adulteration Act require that every tin of condensed (separated or skimmed) milk must have a label printed in large type—"Machine Skimmed Milk" or "Skimmed Milk."

DRIED MILK.

Dried milk is milk in a powder form obtained by removing all water by some drying process; it contains all the solids of milk. It may be obtained from whole milk, skimmed or partly skimmed milk. It is prepared by evaporating milk in a water bath until the required consistency is reached; this is then transferred to a rolling drum through which hot air is driven until it becomes a semi-solid mass. It is then pressed through a sieve, and the granules thus obtained are then reduced to powder. There are other methods, for instance passing milk between two revolving cylinders heated internally by steam to 212° F. The milk forms a thin film and is quickly dried and then scraped off. Dried whole milk contains on an average about 26.8 per cent. Fat, 26.4 per cent. Proteins, 37.8 per cent. Sugar, 5.8 per cent. minerals and 3.9 per cent. Water. By adding one part of dried milk

to 7 parts of warm water a fluid resembling fresh milk in all essential particulars with the odour and taste of boiled milk is obtained. Dried machine separated milk contains only about 1 per cent. fat. The advantages of dried milk are that desiccation reduces the bulk and weight and makes it easily transportable, the elimination of water removes the possibility of microbial activity, and unutilized milk which would go to waste is preserved. Dried milk keeps well but if stored for a long time in cardboard boxes it is liable to acquire a rancid taste due to oxidation of the fat.

Dried milk is good for growing children and adults and is more easily digested by infants as the curd is more flocculent and fairly divided than in fresh milk. Dried milk forms the basis of various proprietary foods, and is used in baking and confectionery trades. It is used in many food combinations, *e.g.*, with Cocoa, Eggs, etc. Recently the fat and non-fatty solids of milk are separately dehydrated, and milk can be reproduced by mixing the two products with water. The products keep better when thus separated.

In the desiccation of milk, the salts of calcium and half of the lactalbumin are rendered insoluble, the ferments are destroyed and half the Vitamin C is destroyed but sufficient is left over to prevent scurvy in children. Milk sugar is unaffected.

Boiled Milk.

For domestic purposes milk, if boiled, will keep for a certain length of time. Boiling destroys all pathogenic germs, but sporing and certain highly resistant forms of bacteria may survive. By boiling, milk alters in taste due to the decomposition of certain proteins and the loss of certain gases. The following are the other changes which may occur:—

1. The fine emulsification of fat is partly destroyed and some of the fat globules coalesce,
2. Salts of calcium and magnesium and phosphates are precipitated,

3. Proteins and complex nitrogenous compounds are partly decomposed,
4. The lactose is burnt, or "Caramelised" and becomes brownish in colour,
5. Ferments are destroyed,
6. The germicidal power of milk is lost,
7. Some of the Vitamins chiefly C are affected,
8. Carbon dioxide is expelled.

It has been, however, found experimentally that boiled milk does not suffer as regards its digestibility or nutritive value.

When milk is heated in an open vessel to about 60° C and over, a pellicle consisting of coagulated casein and salts is formed, which if removed, is reformed.

PASTEURISED MILK.

Pasteurisation is a term applied to a process of heating milk to a certain temperature below its boiling point, maintaining at that temperature for a certain period, sufficient to kill all the pathogenic and harmful bacteria without destroying the nutritive properties, and then chilling it rapidly. 99 per cent. of the Bacteria are killed by pasteurisation but certain spore bearing bacilli will survive and the toxins of the bacilli may not be destroyed. Opinions differ as to the length of time the milk should be exposed to a certain specified temperature. It is well-known that heating milk at 140° F (60° C.) for twenty minutes is sufficient to kill the bacilli of Tuberculosis, Typhoid, Dysentry, Cholera and all other non spore-bearing milk borne infections which affect man. For every degree above 140° F the time may be reduced by one minute.

There are two main types of Pasteurisers devised. (1) Continuous flow (flash) pasteuriser in which the milk is heated for a minute to a temperature of 70°-80° C by allowing

it to flow in a thin film on the outside of a steam coil and then chilling it rapidly by passing it over cold metal. This method is rapid and cheap but is not reliable as it does not give uniform results.

(2) The Retainer Pasteuriser in which the milk is heated to 60°–65° C and held at that temperature in a suitable tank for thirty minutes and then rapidly cooled. This method is more satisfactory as the pathogenic bacteria are killed with certainty. The milk should be immediately bottled and sealed by machines, kept cooled, and promptly distributed. The bottles should be cleaned by steam or scalding water.

Milk can be pasteurised in the "final container" of milk bottles. The milk bottles are corked and sealed and placed in a water bath at 148°F for thirty minutes and then placed in ice. This method with some modification can be used for home pasteurisation. Pasteurisation is a preventive measure of the greatest importance and utility. It is the simplest, cheapest, and most reliable method of rendering milk safe. It does not alter the taste, appearance, flavour or food value of milk. It may increase its digestibility by rendering the curds smaller. It may, however, destroy a part of the Vitamin C. Pasteurisation, however, cannot atone for filth and insanitary methods of production and handling of milk. There have been no instances of milk borne epidemics being conveyed by pasteurised milk. An objection raised against pasteurisation is that it encourages uncleanlines and carelessness in the production of milk but this idea is disapproved of by the experience that the milk supply of large cities has improved with pasteurisation.

Pasteurisation plants should be properly designed, well-run, and kept in a clean and efficient condition. There should be automatic temperature-control and temperature-recording arrangements. The thermometers and thermo-regulators should be checked from time to time and the

milk tested chemically and bacteriologically every day to verify the effectiveness of the process. There must be proper and responsible supervision to ensure the proper working and cleanliness of the plant.

There are various electric processes available which are supposed to render milk safe, without producing any of the detrimental effects on the quality of milk resulting from heating milk. Some of them are no more than "flash" pasteurisation plants, the heat being produced by electricity, and experimental proofs are still required to endorse the claims of the manufacturers of these commercial processes.

IRRADIATED MILK.

Ultra-violet irradiation of milk has been known to improve its antirachitic properties by increasing the amount of Vitamin D. It has been suggested that wholesale irradiation of milk should be undertaken to prevent rickets. Milk can be irradiated by exposing it within a closed quartz tube or by allowing it to trickle in droplets down a gauze cylinder surrounding a long mercury vapour tube. Irradiation in an open vessel is objectionable as the colour becomes yellow, the taste disagreeable and a smell of ozone is imparted; besides over-exposure destroys vitamin D and the ferments and increases the clotting time with rennet.

Irradiated milk has beneficial effects on anaemic children, the red blood count being considerably increased. Vitamin A is not destroyed, but the fate of vitamin C is doubtful but this is of no consequence as the amount is so little and unstable that milk can never be relied on as a source of vitamin C.

HOMOGENIZED MILK.

The fat globules in normal milk have a tendency to coalesce into tiny clusters or masses. In pasteurised milk specially after a long journey the fat will rise to the top

forming a butter like mass due to the shaking and jolting during transport. One customer will therefore get milk very rich in fat and another with a great deficiency.

In homogenization the milk is pumped at a temperature of about 75°C against a cone shaped agate stone at a pressure of a ton and a half to the square inch. The fat globules are thereby broken up into fine particles, which remain uniformly and permanently distributed throughout the milk and do not rise to the top to form butterlike masses. The cream will thus be evenly distributed and a rich quality of milk is thereby obtained. It is not possible to obtain cream and butter from homogenized milk.

STERILIZED MILK.

Milk may be sterilised and thus protected from fermentation and decomposition by heating it to a very high temperature usually 120°C for 25 minutes. Milk properly sterilized and bottled will keep indefinitely and can be exported. If a sharp jerk is given to a bottle of sterilized milk a click will be caused by a water hammer knock, due to the vacuum formed in the bottle when the heated milk contracts during cooling. Some observers hold that children fed on sterilized milk are likely to suffer from Scurvy and Rickets. Milk can also be sterilized by electricity and ultra-voilet rays.

This method has not been found to be suitable for commercial purposes in India, for to sterilize milk it would be necessary to raise the temperature to a higher degree than that of boiling water, by heating it in sealed chambers under steam pressure. Such heating would kill all germs and their spores but would alter materially the taste and appearance of milk. It has been found by analysis that ordinary sterile milk (sic) sold in the European markets is not sterile at all but contains many varieties of bacteria.

REFRIGERATED MILK.

This is an excellent method of preserving clean milk for a considerable time and retaining its freshness and substances. In this method if the milk is kept between 0°C to 10°C, the bacteria in the milk are not killed but do not multiply to such an extent as they would in ordinary temperatures. In consequence it would prevent the increase of toxic products. It is therefore obvious that milk should be cooled at the place of collection and not after its transit to the milk vendors. Refrigeration is now done in ocean going steamers, where refrigerating chambers are provided.

Milk is not necessarily safe because it has been kept at a very low temperature. It would depend on the initial number and kind of bacteria present. Refrigeration cannot destroy the injurious bacteria or atone for filth.

There are several forms of refrigerators now available which are very convenient for storing food stuffs at a low temperature. The household ice-box may not on account of faulty construction, insufficiency of ice, or carelessness, maintain a low temperature for any appreciable length of time. If placed near the kitchen stove or if the doors do not fit well, the temperature will rise and form a good incubator favouring bacterial growth.

GRADED MILK.

Milk may be graded into certain classes according to the sanitary quality and nutritive value so as to enable the consumer to realise the standard of the milk he is consuming.

The Committee of Milk Standards of the New York Milk Committee recommend three Grades—Grades A. B. and C.

Grade A.—1. Raw Milk—The milk must be from animals free from disease, and Tuberculin tested. The number of microbes per c.c. should not be more than 10,000.

2. Pasteurised Milk.—Bacterial count before pasteurisation should not exceed 200,000 per c.c. and 10,000 after pasteurisation.

Grade B.—The Bacterial count should not exceed 1,000,000 per c.c. and 50,000 per c.c. if pasteurised.

Grade C.—Bacterial count is above 1,000,000 per c.c. and less than 50,000 after pasteurisation.

In England by the Milk (Special Designations) order 1923, milk may be sold under the following designations. Certified, Grade A (Tuberculin Tested), Grade A, and Pasteurised.

Certified Milk.—The milk must be from animal free from disease and tuberculin tested every 6 months. It must not contain more than 30,000 bacteria per c.c. nor Bacilli Coli in .1 c.c. and it must not at any stage be heated.

Grade A (tuberculin tested).—The milk must be from animals free from disease and tuberculin tested every 6 months and must not contain more than 200,000 Bacteria per c.c. nor B. Coli in .01 c.c.

Grade A Milk.—The cows must be examined by the Veterinary Inspector every three months and the milk must not contain more than 200,000 Bacteria per c.c. nor any B. Coli in .01 c.c. and must not be heated. If pasteurised, it must contain more than 30,000 Bacteria per c.c. nor B. Coli in .1 c.c.

Pasteurised Milk.—The mode of Pasteurisation is laid down and the milk must not contain more than 100,000 Bacteria per c.c.

CERTIFIED MILK.

The term certified milk was first used in America to designate genuine and clean milk produced under the supervision of the Medical Milk Commission who exercised a strict control over the sanitation of the dairy, examination of cattles by Veterinary Surgeon, Medical Supervision of the employees and Chemical and Bacteriological Examination of the Milk. Rosenau defines certified milk as "the very best, the very freshest, the very cleanest, the very purest and the very safest raw milk."

The dairies are periodically inspected and the milk frequently examined. The cattle must be free from any infectious disease or ailment or condition which will deteriorate the milk, and must be proved free from Tubercle by the Tuberculin test. Special requirements for the housing of the animals in clean sanitary, well ventilated stables, and for the proper tending and feeding are laid down. The water supply must be proved to be pure and the employees free from any disease which may be conveyed through milk, and must not be carriers of Tuberculosis, Typhoid, etc. The Milk drawn under all sanitary precautions must be immediately cooled to 45°F and placed in sterilised bottles and kept between 35°F and 45°F.

Certified milk in America must not contain more than 10,000 microbes per c.c.

Dr. Joshi in his book has suggested the following three grades of milk for India.

1. First grade "Certified" Milk.—This should contain at least 6.5 per cent. fat and 9 per cent. non-fatty solids. The number of microbes per c.c. should not exceed 100,000.

2. Second grade or "ordinary" market milk—It should contain at least 5 per cent. fat and 8.5 per cent. non-fatty solids. In the case of cow's milk, the lowest limit of fat should be 3.5 per cent. The number of microbes per c.c. should not exceed 1,000,000.

3. Third grade or "Skimmed" Milk.—This should contain at least 9 per cent. of total solids. All the three grades of milk must be pure, derived from healthy animals and free from dirt and adulteration as well as from Pathogenic Microbes.

The Score Card System.—Is essentially an American idea. It is a card, wherein various marks are allotted to the equipment of dairies, *e.g.*, construction of the stables, location, lighting, health of the animals, etc., and to the methods of milking adopted, *e.g*, cleanliness, handling of milk, etc.

About 40 points are alloted for equipment and 60 for methods. An inspector on inspecting a dairy assigns marks according to the efficiency, as an examiner corrects an examination paper, and from the total number of marks secured by a dairy an idea can be formed of its excellence. A dairy which is not provided with up to date equipments can score good marks by cleanliness, etc., in the methods adopted as 40 marks are assigned for the former and 60 for the latter. The advantages of this system are that the Medical Officer of Health can from the Score Card judge the condition of the dairies and suggest improvements in the particular items in which the dairy has scored low marks. It would help in the certification of milk and enable the public to sort out the good and the bad dairies.

FROZEN MILK.

Recently milk has been frozen into solid blocks by a process, called the "Cito-gel" process. This consists in spraying the milk into vessels which are kept in a freezing chamber, the temperature of which does not exceed-25°C. As soon as the milk falls into the vessels, it gets frozen and solidified. Blocks of solid milk of any size may be prepared by this process, and besides preserving the milk the process enables transport of milk over long distances. The solid milk when exposed to air, takes from 4 to 24 hours depending on the size of the block to be defrosted. The defrosted milk shows no change in its appearance or taste or other characters. The cream rises without difficulty and butter and ghee may be prepared from the same. The milk, in fact, behaves in the same way as before freezing. A block of milk prepared in this way was in good condition 9 weeks after its preparation.

The process has been successfully demonstrated in Bombay and if established on a commercial basis, will enable the import of milk into Bombay from Gujerat and other parts of the country.

PREPARATIONS FROM MILK.

Cream.—When milk is allowed to stand undisturbed the fat globules rise to the surface, as their specific gravity is lower than that of the entire milk. This supernatant layer of fat globules is called cream. Cream may also be obtained by mechanical means, by the use of a centrifugal separator, and this is done especially when cream is needed for commercial purposes. The colour of cream is yellowish white, due to lactochrome, but the commercial cream is sometimes heightened in colour by means of annatto. The amount of fat in domestically prepared cream varies according to the time which has been allowed for its separation; on an average it is about 18 per cent. but may range between 40 and 50 per cent.

Junket.—Is prepared by the addition of rennet to milk and allowing to stand until it coagulates. It is composed of whey and curds and is largely used in the sick room.

Whey.—Is prepared by the addition of rennet or some weak acid to some warmed milk and setting it aside until it is firmly coagulated. The coagulum is then cut into pieces and transferred to a muslin cloth and hung up and filtered through cloth. It forms a pleasant sweetish sour drink and contains all the soluble proteins (1.24 per cent.) milk sugar (4.45 per cent.), fat (0.2 per cent.), mineral salts (0.65 per cent.) and water (93.6 per cent.) If added in equal bulk to cow's milk, it renders the composition of the milk nearly equal to that of human milk. Whey is recommended in Enteric fevers, in catarrhal conditions of the alimentary canal and chronic renal diseases.

Butter Milk.—Is the fluid which remains after butter is prepared, and is as useful as whey in dietetics. It contains more fat and proteins than whey. Butter milk contains about 8 per cent. of milk solids. Butter milk prepared domestically is superior to that obtained from the separator, as it is acid in reaction owing to the development of lactic

acid during the "ripening" of the cream. It is most useful in cases of Gastro-Enteritis as the casein forms flocculi which are more readily digested in the stomach.

Fermented and sour milk.—When fresh milk is exposed to air, it absorbs some acid-forming bacteria which multiply in the milk and render it acid. The most common of these is the Bacillus acidi lactici; it produces enzymes which act on the milk-sugar converting it into glucose and galactose and finally into para and laevolactic acid. The conversion of milk-sugar into lactic acid goes on continuously until it attains a proportion of 1 per cent. when the acidity formed checks further multiplication of bacteria and secretion of enzymes and the milk coagulates spontaneously. Sour milk is largely used in Diabetes, as it is practically sugar free, and in gout as it reduces the formation of toxins from nitrogenous foods. It is also useful in renal diseases. Sour milk, on account of the lactic acid it contains, exercises an antiseptic action on the alimentary canal and checks and arrests the growth of pathogenic and putrefactive bacteria. As developed in the sour milk, lactic acid has a more powerful action than the lactic acid artificially prepared. Metchnikoff strongly advocates the use of lactic acid organisms as a means of strengthening life by preventing fermentative changes going on in the alimentary canal. As a result of his teaching, artificially soured milk has come strongly in public favour and is being largely consumed. Several dairy companies sell sour milk thus prepared for immediate consumption; it is prepared from pasteurised milk to which a culture of lactic acid organisms is added.

Koumiss originally prepared in Russia from mare's milk is now produced by the fermentation of cow's milk by the addition of cane-sugar and yeast. It is easily digested and absorbed and is useful for invalids.

Kephir is a similar drink prepared in the Caucasus by the addition of Kefir grains containing yeast and various micro-organisms to milk.

Mava.—Is desiccated milk; it is prepared for commercial purposes by exposing milk in pans to a slow heat. It is sold in Indian bazzars in pieces and used in the preparation of sweets and ices.

Basundi.—Is another preparation of milk. It is prepared in the same manner as Mawa, but the process stops when the milk has come to a thick consistency: condiments are then added and well mixed. This makes a highly delicious preparation and is indulged in by the wealthy. It is exposed for sale in brass lotas, where it may be contaminated, or kept long enough to develop ptomaines. Instances have been known where whole families have suffered severely after indulging in this preparation. The symptoms were of severe gastro-intestinal irritation not unlike Cholera.

Butter.—When the cream of milk is violently agitated in a suitable apparatus the fat globules coalesce entangling some of the serum and casein and form butter. The whitish liquid in which the particles of butter float is butter milk. The butter is then pressed to squeeze out some of the moisture and salt may be added to preserve it.

The approximate constituents of butter are :—

Fat	83	per cent.
Curd	1.0	"
Ash	1.5	"
Milk Sugar	1.0	"
Water	13.0	"

The legal limit in Bombay for moisture is 16 per cent. Butter fat consists of the glycerides of the fatty acids palmitic, stearic, and oleic which are insoluble in water, and also of the glycerides of certain fatty acids which are volatile and soluble in water principally Butyric acid.

The great distinction between butter fat and animal or vegetable fats is that the former contains about 8 per cent. of volatile fats whilst the latter hardly ½ per cent. Fresh

butter contains a great number of micro-organisms and may contain tubercle bacilli, typhoid and other pathogenic bacilli. Butter turns acid and rancid in time due to the conversion of fat into fatty acids. This rancidity can be removed by washing the butter with water to which soda bicarbonate has been added to neutralise the acidity.

Genuine Butter and Ghee should have a Reichert Wollny figure of 24 and a Butyro Refractometer index of 40.5—44.2 at 40°C whereas vegetable oils and animal fats show a R. W. of less than 2 except cocoa-nut oil which has 8. Butter is very often adulterated with vegetable product (Hydrogenated Vegetable oils).

Ghee.—Ghee is clarified butter and is largely used in India for the preparation of various kinds of food and sweetmeats. It is also taken along with rice, dhals, curries and other article of foods.

It is prepared either from the milk of the cow or buffalo. The milk is first boiled and then curdled. After the lapse of about six hours, the curdled milk is churned, a little water being added so that the butter floats to the top. The butter is then collected, washed in water, and boiled in an iron pan placed over an open fire. The effect of this is to melt the butter, the casein and water falling to the bottom. The floating Ghee is then finally strained and stored in earthen-ware vessels or in tin cases.

In Bombay most of the Ghee comes from certain places in Gujerat and Kathiawar, but there are certain premises in this city which are used for the manufacture of Ghee. They are situated in one locality on the ground floors of dwelling houses in a thickly populated area. There is no preliminary manufacture of butter on these premises. Butter is brought in baskets from upcountry and melted on the premises. Genuine Ghee should be clear, white or slightly yellowish in appearance, and agreeable in odour. If it is dirty or has a rancid smell, it should be condemned.

Since the importation of vegetable product into India Ghee is largely adulterated with it, very often wholesale fraud being committed by vegetable product being sold as Ghee as it very much resembles it.

Besides the hydrogenated vegetable oils, Ghee is also adulterated with animal fats, and hydrogenated fish oil *e.g.*, Whale.

Margarine.—Vegetable or animal fats are melted, strained, cooled with ice and worked up with a little milk, artificially coloured and salted. The product is an article very much resembling butter. The vegetable oils used are cotton-seed, sesame, earth-nut, cocoanut, and animal fats, beef and mutton fats.

Margarine is less digestible than butter and is deficient in vitamins. In England all foreign fats made to resemble butter, and whether mixed with butter or not must be labelled as Margarine. It is not legal to sell Margarine with more than 10 per cent. of Butter fat.

MILK SUPPLY OF BOMBAY.

About 300,000 pounds of milk are required daily for Bombay which amounts to 4 ozs. per head per day.

The sources of milk supply of Bombay are the local, suburban, and up-country. There are 95 licensed milch cattle stables in the city with about 15,000 buffaloes stabled therein. These stables supply 83 per cent. of the requirement of the city and 17 per cent. is brought from outside. Milk from the milch cattle in Bombay is either sold by individual vendors who hawk about from house to house or is sold by sweetmeat sellers in milk-shops or is supplied by Dairies who act as "middlemen." The suburban supply is from the various villages along the two railway-lines. It is generally drawn under insanitary conditions and conveyed in the most primitive manner. There are no special milk trains or wagons, the milkmen placing their open milk cans under the dirty benches. Milk also comes from distant places like Poona.

The milk supply of Calcutta is obtained from three sources:— (*a*) the adjoining country districts, (*b*) suburban, (*c*) local. In contrast to Bombay, there is a much larger number of cows than buffaloes.

The milk supply of the other large cities in India is somewhat on the same lines as Bombay and Calcutta but with few local differences.

DAIRY INDUSTRY IN INDIA.

The Dairy Industry in India, with rare exceptions, is in a most deplorable condition. The milk trade is mostly in the hands of Gowlis whose ignorance and apathy are responsible for the deterioration of cattle and the primitive methods of collection and distribution adopted.

The following causes are ascribed to the diminution in number of good cattle. (1) Lack of scientific breeding, (2) exportation of some of the good breeds to foreign countries, (3) defective feeding and tending of animals, (4) slaughter of "dry" animals in large cities, (5) periodical famines, (6) improper methods of rearing of calves.

The condition of the cattle sheds in India as regards construction, ventilation, accommodation, and sanitation leaves much to be desired. The animals are usually huddled together in insanitary sheds, with *kachha* floors covered over with a thick layer of excreta of animals, and with no drainage, or if any, to a cesspool which is never emptied. In the Presidency towns however, Municipal by-laws are now being brought into operation for the provision of proper sanitary stables with sufficient cubic space and accommodation for each animal, adequate drainage and proper conservancy under the supervision of the Health Department.

The mode of collection and distribution of milk is perfunctory. The milkmen may, or may not, wash or clean the udders or may only just throw water on them. The dust-laden tail, whisked about to drive away the flies, adds its quota to the milk. The hands of the milkman may be full of dirt and without any attention to cleanliness, he

proceeds with the milking of the animal in any filthy corner of the stable. The milk-man may be a "carrier" of some disease. A brass vessel or lota receives the expressed milk, with all the dirt of the hands, udders, and tail added on to it. The vessel is usually covered along the edge with concentric rings of hay or straw promiscuously picked up from anywhere. There is usually no lid, to prevent the ingress of dust and dirt. The vessels are either carried on the head of the hawkers or allowed to hang from a pole slung across the shoulder, and ultimately sold directly to the consumer or exposed for sale, without being covered up, in milk-shops by retail vendors where it may be further contaminated by flies and dirt.

REMEDIAL MEASURES.

Whilst a pure and clean milk supply is a great boon and a blessing, an impure one is responsible for more sickness and mortality than any other food. Milk may undergo decomposition before it reaches the consumer or it may be contaminated with pathogenic microbes directly through pollution or indirectly through adulteration. A large number of diseases may thereby be conveyed through milk. The problem of producing, handling, transporting, and distributing milk in a clean and fresh state is one of the most difficult and intricate problems which the Sanitarian has to tackle.

The following points have, therefore, to be considered :—

(1) Improvement of milch cattle, (2) feeding, (3) housing and breeding of cattle, (4) collection, preservation, transportation and distribution of milk, (5) educational measures and (6) Legislative control.

(1) *Breed.*—The quality and quantity of milk varies with the breed of the cattle and the production of a class of animals the female of which will be an excellent milker is a problem for the agricultural experts. In India there are various breeds with great differences in the composition of milk and systematic attempts should be made by the Agricultural Departments to improve the milk producing qualities of Dairy cattle.

(2) *Feeding.*—The quantity and quality of milk are largely dependent on the amount and class of food given to the cattle. This, too, is a purely agricultural problem. The supply of an adequate amount of good fodder at a low cost and an abundant supply of water are essential for the rearing of cattle on economic lines.

(3) *Housing and tending.*—Housing and tending are important factors on which the quality of milk produced depends. The animals should be housed in sanitary stables with an efficient drainage and pure and abundant water supply, and should be protected from sun, rain and wind. The animals would be better looked after in the hands of careful individual Gowlis than in a large commercial Dairy farm, as the former would take greater interest in their animals. The consensus of opinion is that the cattle should be shifted to the suburban villages near the railway line rather than be stabled in the city.

The following advantages and disadvantages of the city and country for milch cattle stables are reproduced from Dr. Joshi's "Milk problem in Indian Cities":—

(*A*) IN THE CITY.

(Advantages.)

1. Proper sanitary supervision and legislative control.
2. Easier access. The milk has not to be transported a long distance.
3. Greater likelihood of a pure and abundant supply of water, and better drainage.

(Disadvantages.)

1. Higher rents for stables, etc.
2. Feeding more expensive.
3. Lack of exercise and fresh air which are important for a good yield of milk.
4. Waste of valuable manure.
5. Insanitary and unhealthy surroundings for the cattle.
6. Nuisance or danger to human dwellings in the neighbourhood.
7. Too expensive for keeping dry animals and raising young stock. This leads to the slaughter of the dry animals and neglect in the rearing of calves.
8. Milk is more likely to be contaminated with dirt, dust, bacteria, etc.

(B) IN THE COUNTRY.

(Advantages.)

1. More economical.
2. Possible to raise one's own fodder.
3. Grazing and exercise in the fresh air which slightly improve the yield of milk.
4. Manure can be utilized for "intensive" farming.
5. More natural and healthy surroundings.
6. In epidemics, isolation of cattle is easier.
7. Milk is less likely to be contaminated with pathogenic bacteria, dirt and dust.
8. The taste of the milk is better in the country than in the city.
9. Scientific breeding can be undertaken.
10. Cheaper to maintain dry animals and raise young stock.

(Disadvantages.)

1. Lack of proper sanitary supervision and control.
2. The water-supply is likely to be scanty and bad.
3. The chances of adulteration with water during transit are perhaps greater.
4. The cost of preserving milk (by pasteurisation, etc.), for long distances, and the difficulty of rapid and cheap transit to the city.

PRODUCTION AND COLLECTION.

For the production and collection of clean milk scrupulous attention must be paid to the process of milking to avoid the admittance of any dust, dirt and bacteria. The animal must not be milked in the same place where it is tethered but in a special, clean, well lighted sanitary milk shed. Each animal must be washed thoroughly before milking, specially the udders, tails and surrounding parts. Greater the care at the time of milking, the longer the milk will last. The hands and clothing of the milker must be quite clean and all the sanitary precautions against sneezing, coughing, spitting should be rigidly observed. The milkman should not be a carrier of Tuberculosis, Typhoid, etc. The milk pails should be washed with washing soda and water and then cleaned with boiling water before use. From the milk pails the milk is collected into large cans and then cooled or pasteurised according to the distance it has to travel, and bottled and sealed. To obviate the contamination of the

milk from human source, milk machines are used abroad as a substitute for hand milking. If milk has to come from the country, there must be facilities for cheap and rapid transit in motors or waggons. In railway trains there should be cooling compartments with plants for maintaining a low temperature during travelling. The milk will finally find its way to the home directly or through the milk depot or shop. In both these places there is a possibility of milk being contaminated and special care is therefore required to prevent the entry of dust and dirt.

Distribution.

The problem of distribution of milk is, if anything more difficult than that of production. If the purveying of milk is left in the hands of petty individual dealers it is difficult for the Health Officer to exert any strict supervision, and it is impossible to stop adulteration. From the sanitary, economic, and administrative points of view it would be easier to control a few large concerns, *e.g.*, Co-operative Societies or large private concerns than petty vendors. The milkmen should be induced to leave the city and shift their cattle to sanitary stables in the suburbs where milk can be produced on more economical and natural conditions. They should be organised into one or more co-operative societies which could collect the milk in bulk under hygienic control and transport it to the city under ideal conditions. The societies would be able to engage competent staff and purchase all the modern implements, plants and modes of transport. The Co-operative Society could further help the Gowli with loans at low rate of interest, afford them facilities to buy good food at cheap rates, improve the breed of cattle, take care of the dry cattle, and supervise over the sanitation of the stables.

Private companies with large capital could also take up the city milk trade buying milk from the indigenous producers. It would not be advisable for any company to

take up Dairy Farming on a large scale as it is not likely to be successful.

EDUCATIONAL MEASURES.

The public must be educated through lectures, demonstrations, exhibitions, and the press regarding the danger to health of an impure milk supply and the precautions to be taken in handling milk. It is only when they demand and insist on wholesome milk will the supply of pure milk be forthcoming. A great educational campaign must also be undertaken to overcome the ignorance and prejudices of the Indian milkmen and to teach them the modern methods of economic and sanitary milk production.

LEGISLATIVE CONTROL.

The hands of the Public Health Department should be strengthened so as to enable it to exert an efficient sanitary and legal control on the production and distribution of milk, and organise generally the milk trade. Bye-laws regulating the location and the sanitary requirements for the housing of milch cattle, control over the production, transit and distribution of milk through licenses and permits, bacteriological examination of the milk supply with a view to checking adulteration and the addition of preservatives, an efficient system of inspection through milk Inspectors and Veterinary Surgeons, are some of the directions in which improvement is gradually being made in the large cities of India. The organisation of suitable agencies, *e.g.*, Co-operative Societies, private companies with capital for the collection and distribution of milk, and the provision of improved facilities and the cheap and sanitary transport of milk from the suburbs are the lines on which the future improvement of the milk trade in India should be centred as to ensure a clean, pure and cheap milk supply.

CHAPTER VII.

SOILS AND BUILDING SITES.

Soil, from a sanitary point of view, is defined by Parkes as that portion of the crust of the earth which by any property or condition can affect health. It is divided into (*a*) the *surface soil*, and (*b*) the *sub-soil*.

A perfectly pure soil would consist of certain mineral matters, the result of the weathering or decay of the subjacent rocks. Soil contains in addition organic matter of both vegetable and animal origin, air and water.

The physical and chemical constitution of the soil, and the configuration of its surface have an important bearing on many sanitary questions, such as water-supply, burial grounds, sewage land treatment, sites for buildings, and the prevalence of certain diseases.

GROUND-AIR.

The air in the soil or *ground-air* varies in amount primarily according to the density of the soil. The very hardest rocks such as basalt contain no air, loose sand may contain 50 per cent., whilst between these two extremes, there are all possible variations in amount. Loose dry soil freshly ploughed, such as we commonly see in this country, may contain as much as ten times its own volume of air. It lies above the *ground-water* level and fills all the space unoccupied by water or solid particles.

The *ground-air* is generally impure. It contains moisture, and sometimes ammonia, sulphuretted hydrogen, and marsh gas due to decomposition of organic matter of animal and vegetable origin. It is specially rich in CO_2, and in addition it may carry upwards with it, numerous micro-organisms from their breeding place in the soil. In the neighbourhood of houses, the foulness of the ground-air is

often due to contaminations from leaking cesspools, sewers and drains, and sometimes this pollution may be dangerous owing to infected excretions.

The ground-air is in continual movement owing to (*a*) *the variations in the diurnal temperature* which cause differences between the soil and atmospheric temperature, so that the air passes from the warmer to the colder medium, whichever it may be ; (*b*) *the permeability of the soil,* the movement being very free in loose soils, and much less so in the hard rocky soils ; and (*c*) *the varying levels of the ground-water,* and *the occasional fall of rain,* both of which naturally displace air from the interstices of the soil. The understanding of these movements of the ground-air is of great importance, because in addition to excess of CO_2 and ordinary organic effluvia, serious and dangerous pollution from leaky cesspools and drains occurs, as mentioned above, and owing to the defective structure of an ordinary house, such tainted air is likely to enter the building. Many houses have deep foundations excavated often in close proximity to leaking sewers or cesspools. The ground floors of such houses have generally a pervious floor of earth, brick, or badly pointed stones, through which, owing to the high temperature in the house the ground-air is actually sucked in, and ascends to supply the various rooms. It will therefore not be considered surprising, that many attacks of diseases of insidious or inexplicable nature, are likely to occur among the inmates of such houses.

GROUND-WATER.

In a porous soil, at a certain point below the surface, all the pores are full of water, to the complete exclusion of air. This ground or sub-soil water extends downwards to the next impermeable layer. In marshy ground the sub-soil water may reach the ground level. In ordinary conditions its level may vary from 2 to 3 to 100 feet or more below the surface of the ground. The level of the sub-soil water

is not necessarily horizontal or parallel with that of the ground. Its usual flow is in the direction of the nearest water-course or sea, and the velocity of its flow depends on the porosity or permeability of the soil, the steepness of the gradient, and the absence of obstruction caused by roots of trees. The principal source of this ground-water, is that portion of the rain which percolates into the soil. Hence its level is affected by rainfall, also by the height of water in adjoining streams or rivers or seas, and other conditions modifying the facility of outflow, such as artificial drainage. In this country the level probably varies from 5 feet during the rains to about 20 feet at the end of the hot weather, but there are doubtless many exceptions to this.

The soil though aerated above the level of the sub-soil water, is kept moist by capillary attraction, by evaporation from below, by rainfall, and by the movements of the ground-water. When the ground-water rises, it forces the air out of the soil, and at the same time, may contaminate wells by introducing into them the impurities of polluted soil. As the ground-water falls again, it leaves the soil moist and full of air, and thus brings about conditions favourable for fermentative and putrefactive processes in organically polluted soil.

The most important property possessed by soil, owing to the presence in it of micro-organisms is that of *nitrification*, whereby organic matter is split up into its simplest constituents, so as to be readily made use of by vegetation. Plants are unable to obtain their supply of nitrogen direct from complex organic bodies, but owing to the action of bacteria, these are so decomposed, that their nitrogen becomes converted into ammonia, and thence into nitrites and nitrates, in which form plants can take up their required nitrogen. Although a large number of the miro-organisms present in the upper layers of the soil are harmless, still certain bacilli which are capable of producing disease in man are

occasionally met with in the earth. The chief of these are the bacilli of tetanus, anthrax, glanders, enteric fever, and malignant œdema.

Soil in relation to disease causation.—Telluric conditions are closely connected with certain specific diseases, such as anthrax, tetanus, malaria, enteric fever, diarrhœa, and cholera. In the case of anthrax and tetanus, the soil infection has its source in infected dung. Dampness of soil is also favourable to phthisis and diphtheria. There are endemic areas in which cholera, diarrhœa, and enteric fever prevail, particularly where the soil is polluted with excremental matter. This fact in itself is strongly suggestive of telluric relations in regard to these diseases. Another way in which sub-soil water may produce these diseases, is by polluting the water used for drinking purposes, with their specific organisms. The intimate connection between moisture of soil and phthisis is proved by the fact, that in those towns where damp soils have been drained, so as to permanently lower the level of the ground-water, the deaths from this disease have been greatly reduced.

The connection between malaria and damp marshy soils capable of holding stagnant water in which *Anopheles* mosquitoes can breed is well known. Prior to the researches of Sir Ronald Ross and others, that the *Anopheles* mosquito is the carrier of the parasites of malaria, it was believed that this disease was due to a miasma given off from the soil in a marshy place. There is no doubt a certain amount of truth in this supposition. Malaria is due to a miasma, but the miasma is not a gas or a vapour, but a living insect. The germs of malaria do not live in the marsh. It is the carriers of the germs which live there. It was Laveran who showed in the year 1880, that the "poison" of malaria consists of innumerable, minute, protozoal parasites of the blood corpuscles. Since then, it has been shown by numbers of observations made in many parts of the world, that these

parasites pass another phase of their existence in the *Anopheles* mosquitoes, which in the natural course of events communicate them from the sick to the healthy, by means of their bites. Animal parasites particularly hook-worm, and several other intestinal worms are deposited on the soil and re-infect man during one of the stages of their life cycle.

CHOICE OF SITES FOR HOUSES.

This may be considered under three heads: (1) the aspect or exposure of the site to wind, light, and air ; (2) the actual nature or character of the soil ; (3) the surroundings of the site.

1. In regard to the aspect of any site, there are no two opinions that the brightest and most airy house is generally the healthiest. But it is desirable to avoid exposure to a prevailing cold wind, by securing shelter from it by means of a belt of trees, or some rising ground.

2. As regards the character of the ground or soil on which it is intended to build a house, the aim should be to secure either a naturally dry soil, or one which can be easily drained, and into which the drainage from other sites does not, or is not likely to flow. For this reason all low-lying swamps and hollows should be avoided. If the area is generally flat or level, every advantage should be taken of any slight elevation in order that the house may be built as high as possible. If on the other hand the country is hilly, the actual slopes or sides of a hill are undesirable. The banks of rivers, unless well raised above the highest level of the water, should be avoided. Such localities are difficult to be drained, are usually very damp, and liable to be flooded in the monsoon months. So far as the nature of the soil is concerned, it ought to be porous such as gravel or sand, which does not retain any moisture. The next best soils are the various kinds of rocks, such as granites, clay, slates, limestones, sandstones, and chalk. They have always a good slope, and

drain easily. The loams and stiff clays are, as a rule, bad sites as they are damp. They can however be made healthy by adequate drainage. Pure chalk being permeable, makes a healthy site. But if the chalk be mixed with clay (*marl*), or be underlaid with clay, it becomes impermeable and damp.

The worst soils are the shallow beds of gravel or sand lying on clay; they are usually water-logged. The same remark applies to reclaimed lands near the mouth of rivers, and the *alluvial* tracts, which consist of materials that are the deposit or sludge from rivers. These alluvial soils are almost invariably unhealthy not only on account of their dampness, but also on account of the large quantity of organic matter which they contain. They are credited with producing rheumatism, catarrhs, and neuralgia. "Made soil" *i.e.* soil obtained by filling up with refuse low-lying land, tanks, hollows, etc., should never be chosen. It is certainly unsafe to build upon any such "made soil," until the rubbish of which it is so largely composed, has been exposed to the action of the sun and air for a number of years. Even then, the dwelling built upon it should have an air-proof basement of concrete or some impermeable material. The concrete should be from 4 to 6 inches thick. If this should prove expensive, a layer of well-puddled clay is the next best thing, or a boarded floor basement should be used, leaving a space of at least 9 inches between the under surface of the board and the ground surface. Another plan is to raise the building on arches to keep it sufficiently clear of the ground. The object in all these cases is to disconnect the ground-air from the air of the houses.

One of the most important points to be noticed in all sites is the distance of the ground-water from the surface. It ought not to be nearer the surface than 10 feet, but a depth of 15 to 20 feet below the surface would be decidedly preferable. Frequent, sudden, and extensive changes of water-level

are unhealthy. Therefore a place where the level of the water in a neighbouring well is apt to rise and fall a good deal, is not a good site.

Besides excluding the foul ground-air of "made soils" from houses built on them, measures should be taken to prevent damp from rising in the walls of all houses, by capillary attraction, by inserting what is known as a "damp-proof course". It consists of a continuous layer or course of impervious material, such as slate, glazed earthenware, vitrified bricks, or hydraulic cement laid horizontally for the entire thickness of each wall, above the highest point at which the wall is in contact with the earth and below the lowest timbers or floor supports. The walls of no room or cellar should be in direct contact with the soil. This can usually be done by digging away the earth on the outside to below the level of the floor, so as to form a "dry area". Another plan is to make the wall hollow up to a point above the ground level, and then insert two damp-proof courses, one at the bottom of the hollow and below the floor level, the other at the top of the hollow, and therefore above the outside ground level. In this way the inner wall is completely isolated from the soil.

3. In regard to the third point in connection with the choice of sites for houses, *viz.*, their surroundings, it is necessary to see that the soil or sub-soil is not being fouled by the drainage of any neighbouring building. Thus when one house is located at a lower level than another in its vicinity, it is likely to suffer from the effects of the drainage from the one above. No heaps of refuse or manure or other collection of decaying matter should be near the site. The immediate neighbourhood of sewage farms, factories, grave yards and marshes should be avoided. The irrigation of adjoining land as a rule makes a site less healthy than it ought to be, as it raises the level of the ground-water.

IMPROVEMENT OF UNHEALTHY SOILS.

The two principal causes of unhealthiness of soils are dampness and the presence of decaying organic matter. The former can be mitigated by drainage, and the latter by oxidation and vegetation. Drainage should be both surface and sub-soil. Surface drainage serves the purpose of carrying off rain water with some surface impurities, instead of allowing it to sink into the soil, and thus preventing a rise in the level of the sub-soil water. Sub-soil drainage is effected either by means of deep drains, or by unglazed porous earthenware pipes placed at varying depths of from 1 to 3 feet below the soil-surface and about six feet apart. In this way it provides for the removal of water contained in the soil, or for lowering the level of the sub-soil water.

Oxidation of organic matter in the soil is promoted by free access of air, and by drainage which allows air to permeate the soil. The removal of brushwood and regular tillage, considerably aid this action. The influence of vegetation in purifying and improving soil is of a threefold nature. Firstly, trees keep the surface of the ground cool by protecting it from the sun, thus diminishing exhalation from the soil. Secondly, they promote dryness of the soil and coolness of air in damp places, by taking up moisture by means of their roots and evaporating it through their leaves. And thirdly, they feed upon matters which pollute the soil and the air, and thus act as purifying agents. It has been calculated that an oak-tree evaporates eight and a half times the rainfall over the area it occupies, and the Eucalyptus tree absorbs and evaporates eleven times this amount. The sacred tree of the Hindus, *viz.*, *Tulshi—Ocimum Sanctum*—is said to be a good absorber of moisture, and the date palm or toddy tree also enjoys the same reputation.

Dry cultivation and regular ploughing of the land are always beneficial. The cultivation of "wet crops" such as sugarcane in the vicinity of houses, is not favourable to health,

because such crops require a large quantity of manure and water for their food and growth. An unhealthy low-lying damp soil can also be improved by raising its level, by reclaiming it with clean earth.

After the securing of a suitable site, the next thing is to see that the building proposed to be erected on it is so built as to be considered healthy. A healthy dwelling must satisfy the following conditions :—

(1) A site dry and not organically polluted, and an aspect which affords light and cheerfulness.

(2) A ventilation which removes all respiratory and other impurities.

(3) A pure supply of water.

(4) A system of immediate and perfect sewage removal, which shall render it impossible that the air shall be contaminated by excreta.

(5) A construction of the house which shall ensure perfect dryness of the foundations, walls, and roof.

(6) A construction such as will be amply sufficient to protect from the direct heat of the sun's rays, and to ensure reasonable coolness of the house at all hours. This last-mentioned condition is particularly applicable to buildings in this country.

CHAPTER VIII.

INFECTIOUS DISEASES AND THEIR PREVENTION.

Under the heading of 'Infectious Diseases' are included diseases communicable from man to man and from animal to man.

The list of such diseases in India includes many which are not met with in European countries. A knowledge of the causes and the way in which such diseases are communicated is a necessary part of the education of the Sanitary Official, whether he be the Health Officer or the Sanitary Inspector.

LAWS FOR THE PREVENTION OF INFECTIOUS DISEASES.

The Acts relating to the prevention of infectious diseases in England are :—

The Notification of Infectious Diseases Act, 1889, and the Infectious Diseases Prevention Act, 1890, P. H. (Tuberculosis) Regulations, 1912, 1921 and 1924 ; and P. H. (Tuberculosis) Act, 1921. The first deals with the compulsory notification, by a medical practitioner to the Medical Officer of Health, as soon as he becomes aware of any such case and by the head of the family or nearest relative, and relates to Small-pox, Typhoid (Enteric), Tuberculosis, Typhus, Cholera, Scarlet Fever, Diphtheria, Croup and Erysipelas and sometimes Measles, Relapsing Fever, Puerperal Fever and Phthisis, for which a fee of *2s. 6d.* is paid for every notification by a medical man in practice and 1*s.* 6*d.* for every case occurring in a public institution. The second relates to the prevention of the spread of disease by milk and the disinfecting of premises and clothes and the letting of houses in which cases of infectious diseases occurred and the disposal of bodies of persons dying of infectious disease.

The Public Health Act, 1875, also provides for the provision of hospital accommodation for infectious diseases and the compulsory removal thereto of cases of such diseases.

The Tuberculosis regulations provide for the notification and control of Tuberculosis in all its forms.

The Ministry of Health may at any time declare other diseases notifiable and issue special orders for the control of Plague, Cholera, etc.

In India the laws relating to the prevention of infectious diseases are framed on the above but the wording is different and the diseases are not always specified, the words "any dangerous diseases" being used.

THE BOMBAY MUNICIPAL ACT RELATING TO INFECTIOUS DISEASES.

Section 421. Every medical practitioner who treats or becomes cognisant of the existence of any dangerous disease in any private or public dwelling other than a public hospital, shall give information of the same with the least practicable delay to the Executive Health Officer. The said information shall be communicated in such form and with such details as the Executive Health Officer, with the consent of the Commissioner, may from time to time require.

N.B.—The form used for notification in Bombay is given on the next page.

Section 422. The Commissioner may at any time, by day or by night, without notice, or after giving such notice of his intention as shall, in the circumstances, appear to him to be reasonable, inspect any place in which any dangerous disease is reputed or suspected to exist, and take such measures as he shall think fit to prevent the spread of the said disease beyond such place.

423. (1) If it shall appear to the Commissioner that the water in any well, tank or other place is likely, if used for drinking, to engender or cause the spread of any dangerous disease, he may, by public notice, prohibit the removal or use of the said water for the purpose of drinking.

(2) No person shall remove or use for the purpose of drinking any water in respect of which any such public notice has been issued.

424. (1) The Commissioner or any police officer empowered by him in this behalf may, on a certificate signed by the Executive Health Officer or by any duly qualified medical practitioner, direct or cause the removal of any person who is, in the opinion of such Executive Health Officer or other medical practitioner, without proper lodging or accommodation, or who is lodged in a building occupied by more than one family, and who is suffering from a dangerous disease, to any hospital or place at which patients suffering from the said disease are received for medical treatment.

(2) The person, if any, who has charge of a person in respect of whom an order is made under sub-section (1), shall obey such order.

The certificate is usually in the following form :—

I do hereby certify that in my opinion (Full name and race of patient to whom the certificate relates)——————————
is without proper lodging or accommodation, (lodged in a building occupied by more than one family) and is suffering from a dangerous disease, namely...............................

Place and Date. Signature : Health Officer. / Medical Practitioner.

Order

No. $\frac{\text{VII}}{267}$D

(*Duplicate*).

Name of Street________________

No. of House________________

Name of Patient________________

Sex________________

Age________________

Disease________________

Date________________

Medical Practitioner.

Form of Notification in Bombay City.

NOTIFICATION OF INFECTIOUS DISEASES. (Original.)

Information for the Executive Health Officer, Bombay.

Diseases to be notified are Small-pox, Plague, Cholera, Relapsing Fever, Enteric Fever, Scarlet Fever, Yellow Fever, Diphtheria, Typhus, Tuberculosis, Leprosy, Influenzal Pneumonia and Cerebro Spinal Fever.

Bombay, dated.....................................193 .

Name of Street	No. of House.	Name of patient	Sex.	Age.	Disease.	REMARKS.

N.B.—The attention of the Medical Practitioner is invited to Section 421 of the Bombay Municipal Act, 1888, quoted below.

Executive Health Officer, Bombay. *Medical Practitioner.*

Section 421 :—" Every Medical Practitioner who treats or becomes cognisant of the existence of any dangerous disease in any private or public dwelling, other than a Public Hospital, shall give information of the same with the least practicable delay to the Executive Health Officer. The said information shall be communicated in such form and with such details as the Executive Health Officer, with the consent of the Commissioner, may from time to time require."

On the certificate of——————————————dated ——————————193 , I do hereby, pursuant to the provision of section 424 (1) of the City of Bombay Municipal Act, 1888, direct the removal of—————————————— who is certified to be suffering from the disease of——————————to ——————————being a hospital or place at which patients suffering from the disease of——————————are received for medical treatment.

Place and Date. } Signature :

Municipal Commissioner.
Municipal Officer (empowered under §68)
Police Officer.]

Section 425. (1) If the Commissioner is of opinion that the cleansing or disinfecting of a building, or of a part of a building, or of any article therein likely to retain infection, would tend to prevent or check the spread of any dangerous disease, he may, by written notice, require the owner or occupier of such building to cleanse or disinfect such building or part thereof or article therein and, if it shall appear to the Commissioner necessary, to vacate the said building for such time as shall be prescribed in the said notice.

(2) Provided that, if, in the opinion of the Commissioner, the owner or occupier is from poverty or other cause unable effectually to comply with such requisition, the Commissioner may cause the building or part of the building or article likely to retain infection to be cleansed or disinfected and defray the cost of so doing.

[The notice under section 425 (1) is in the following form :—

To

The OWNER OR OCCUPIER of building No. Street.

Whereas I am of opinion that the cleansing and disinfecting of the abovementioned building will tend to prevent or check the spread of a dangerous disease, namely,

and it appears to me necessary that such building be temporarily vacated. Now in exercise of the power in this behalf conferred on me by section 425 (1) of the City of Bombay Municipal Act, 1888, I do hereby require you to cleanse and disinfect the said building within days from the service hereof, and within the said period to vacate the said building and not to re-occupy the same until after the expiration of from the date on which the same shall be fully vacated as aforesaid.

Place and Date } Signature :

Municipal Commissioner.
Municipal Officer.
Police Officer.

Section 426. (1) If the Commissioner is of opinion that the destruction of any hut or shed is necessary to prevent the spread of any dangerous disease he may, after giving to the owner or occupier of such hut or shed such previous notice of his intention as may, in the circumstances of the case appear to him reasonable, take measures for having such hut or shed and all the materials thereof destroyed.

(2) Compensation may be paid by the Commissioner, in any case which he thinks fit, to any person who sustains substantial loss by the destruction of any such hut or shed; but except as so allowed by the Commissioner, no claim for compensation shall lie for any loss or damage caused by any exercise of the power conferred by this section.

427. (1) The Commissioner may provide a place, with all necessary apparatus and attendance, for the disinfection of clothing, bedding or other articles which have become infected, and in his discretion may have articles brought to such place for disinfection, disinfected on payment of such fees as he shall from time to time fix, with the approval of the Standing Committee, in this behalf, or, in any case in which he thinks fit, free of charge.

(2) The Commissioner may, from time to time, by public notice appoint a place at which clothing, bedding or other articles which have been exposed to infection from any dangerous disease may be washed; and no person shall wash any such article at any place not so appointed without having previously disinfected the same.

(3) The Commissioner may direct the disinfection or destruction of bedding, clothing or other articles likely to retain infection.

(4) The Commissioner may, in his discretion, give compensation for any articles destroyed under sub-section (3).

428. (1) No person who is suffering from a dangerous disease shall enter a public conveyance without previously notifying to the owner, driver or person in charge of such conveyance that he is so suffering.

(2) Notwithstanding anything contained in any Act relating to public conveyances for the time being in force, no owner or driver or person in charge of a public conveyance shall be bound to carry any person suffering as aforesaid in such conveyance unless payment or tender of sufficient compensation for the loss and expenses he must incur in disinfecting such conveyance is first of all made to him.

429. The Commissioner, with the sanction of the Corporation, may provide and maintain suitable conveyances for the free carriage of persons suffering from any dangerous disease; and when such conveyances have been provided, it shall not be lawful to convey any such person by any other public conveyance.

430. (1) No person who is suffering from a dangerous disease shall,—

(*a*) without proper precaution against spreading such disease, cause or suffer himself to be carried in a public conveyance;

(b) cause or suffer himself to be carried in a public conveyance contrary to the provisions of the last preceding section.

(2) No person shall go in company with, or take charge of, any person suffering as aforesaid, who causes or permits himself to be carried in a public conveyance in contravention of sub-section (1).

(3) No owner or driver or person in charge of a public conveyance shall knowingly carry or permit to be carried in such conveyance any person suffering as aforesaid, in contravention of the said sub-section.

431. The owner, driver or person in charge of a public conveyance in which any person suffering as aforesaid has been carried, shall immediately provide for the disinfection of the same.

432. (1) No person shall, without previous disinfection of the same, give, lend, sell, transmit or otherwise dispose of any articles which he knows or has reason to know has been exposed to infection from any dangerous disease :

(2) Nothing in this section shall be deemed to apply to a person who transmits, with proper precautions, any such article for the purpose of having the same disinfected.

433. (1) No person shall let a building or any part of a building, in which he knows or has reason to know that a person has been suffering from a dangerous disease, without first having such building or part thereof and every article therein likely to retain infection disinfected to the satisfaction of the Executive Health Officer or of some duly qualified medical practitioner, as testified by such officer's or medical practitioner's certificate.

(2) For the purpose of this section, the keeper of a hotel or inn shall be deemed to let part of his building to any person accommodated in such hotel or inn.

Special Sanitary Measures.

Section 434. (1) In the event of the city being at any time visited or threatened with an outbreak of any dangerous disease, or in the event of any infectious disease breaking out or being likely to be introduced into the city amongst cattle, including under this expression sheep and goats, the Commissioner, if he thinks the ordinary provisions of this Act or of any other law at the time in force are insufficient for the purpose, may with the sanction of Government,

(a) take such special measures, and

(b) by public notice prescribe such temporary regulations to be observed by the public or by any person or class of persons,

as he shall deem necessary to prevent the outbreak of such disease or the spread thereof.

(2) The Commissioner shall forthwith report to the Corporation any measures taken and any regulations prescribed by him under sub-section (1).

450. (1) In the case of a person who has been attended in his last illness by a duly qualified medical practitioner, that practitioner shall sign and forward to the Commissioner a certificate of the cause of such person's death in the form of Schedule P, or in such other form as shall from time to time be prescribed by the Commissioner in this behalf, and the cause of death as stated in such certificate shall be entered in the register, together with the name of the certifying medical practitioner.

(2) The Commissioner shall provide printed forms of the said certificates, and any duly qualified medical practitioner resident in the City shall be supplied, on application, with such forms, free of charge.

THE INFECTIOUS DISEASES IN INDIA AND THE TROPICS INCLUDE :—

Infectious, contagious or inoculable.	Conveyed by Insects.
Cholera.	Malaria.
Dysentery.	Relapsing Fever.
Tuberculosis.	Plague.
Small-pox.	Dengue.
Anthrax.	Filariasis and
Leprosy.	Elephantiasis.
Erysipelas.	*Kala Azar* and Oriental Sore.
Typhoid Fever.	Yellow Fever.
Typhus Fever.	Sleeping Sickness.
Measles.	
Whooping Cough.	
Diphtheria.	
Scarlet Fever.	
Malta Fever.	
Chicken-pox.	
Influenza.	
Puerperal Fever.	
Epidemic Pneumonia	
Mumps.	
Tetanus.	
Actinomycosis.	
Glanders.	
Hydrophobia.	
Cerebro-Spinal Meningitis.	

Koch has laid down certain conditions as to the microbial origin of communicable diseases, *viz.*:—

(1) The micro-organism must be found in the blood, lymph or diseased tissues of man or animal suffering from or dead of the disease.

(2) The micro-organism must be isolated and cultivated in suitable media outside the animal body, for any number of successive generations.

(3) A pure cultivation thus obtained must, when introduced into the body of a healthy susceptible animal, produce the same disease.

(4) In the blood or tissues of inoculated animal the same micro-organism must again be found.

The first stage in the course of the disease is the "infection" or the introduction of the germs of the disease into the body. The manner in which the infective germ gains access to the body varies considerably.

The period between the date of infection and the onset of the disease is called the *period of incubation*, and varies considerably in different diseases: in Small-pox from 12 to 15 days; in Enteric Fever up to 3 weeks, etc. It is important to know, as accurately as possible, the incubation period* of those affections against which we wish to adopt measures of prevention.

The onset of an attack of most of the commonly recognized communicable diseases is sudden and marked by a rise of temperature or other symptoms such as shivering, convulsions, etc. In some, the onset is insidious, the patient being scarcely able to fix the day on which his illness commenced. The fever, if any, subsequently passes through two more stages, which may be called the *height* and the *decline* of the fever.

Further there is a period of convalescence to follow, which may be short or long.

CONVEYANCE OF THE DISEASE.

Certain diseases may, and doubtless do, depend upon highly specialised obligate parasites, incapable of thriving except in the tissues of hosts. Such organisms, though themselves a product of evolution, may have been evolved in the remote past under conditions of environment never since and perhaps never again to be, reproduced.

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* The incubation periods of the important infectious diseases are mentioned on p. 839.

Notwithstanding, therefore, that all pathogenic micro-organisms are doubtless, especially as regards their pathogenic function, subject from time to time to minor variations within the limits of the species, yet many species of such organisms may have long since attained a high degree of fixity of type and thus exhibit now but little tendency to variation beyond such limits. That such is actually the case with regard to the microphytic causes of some of the diseases, there seems ample epidemiological evidence to show.

In this connection it is important to note that occasional difficulty in tracing particular attacks of a given disease to previous cases is far from justifying hasty conclusions that such attacks have had another origin. The probability of such being the case must depend upon a comprehensive view of the ascertained facts, with regard to the disease in question at least, that is, pending definite knowledge of the life-history of the microphyte upon which the disease depends, the multifarious ways in which infection may have been carried and the difficulty of tracing its carriage by man: such ways must be fully taken into account. Allowance must also be made for errors of diagnosis, untreated and concealed cases, which largely add to the difficulty of following out the casual association between successive and connected attacks. If this difficulty is met with in the early cases of an outbreak, the possibility of tracing back the outbreak to some previous prevalence in a more or less remote neighbourhood, to which it may in reality have been due is entirely prevented.

Certain diseases appear to have special seats or points of invasion that is to say, the viruses upon which they depend usually attack the body by some special channel or channels, and possess little, if any, ability of primarily establishing themselves elsewhere. This appears to be the case with regard to the poisons of Diarrhœa, Cholera and Enteric Fever, which make their assault upon the intestinal mucous membrane, and with regard to the poison of Pneumonia which attacks the lungs, and Diphtheria which attacks the tonsils and the throat.

These facts are of considerable importance with respect to the spread of such diseases, for it is not sufficient, in cases of the kind, that the poison should simply be brought to the body, but it must be conveyed also to the particular part of the body which is vulnerable to it. Here we find an analogy in the behaviour of the parasitic fungi which produce the diseases of plants. Some of these attack the flowers, some the fruit, and some the roots.

Take, for instance, Enteric or Cholera; we know that these diseases are caused by a poison introduced directly into the intestinal canal by mouth. We know that the food or water-supply is infected directly or indirectly from a previous case of the disease by these channels and this knowledge has enabled us to prevent the spread of these diseases by sanitary precautions outside the dwellings.

The difficulties of obtaining information from the friends and relatives of infected people and the passive resistance to any sanitary measures make it extremely difficult to trace cases of infectious disease or to adopt measures for their control.

Indifference and carelessness on the part of the poor people to accept any advice adds to the difficulties of control, while the ignorance of any measures of personal hygiene and the rooted objection to any innovation in their domestic arrangements form obstacles difficult to overcome.

Human Carriers of Disease.

A "carrier" is a person who harbours a pathogenic organism, without himself giving any evidence of the symptoms of the disease. Within recent years, the "carrier" problem has received a good deal of attention from public health officers and bacteriologists. In the old days outbreaks of diseases which could not be traced to any definite source, were attributed to infection retained in fomites. But since investigations have been carried out to show that mild and unrecognized cases of certain diseases act as transmitters of infection, this old belief in infection being conveyed by inanimate objects is losing ground.

Up to now the diseases, which have been found to be conveyed by human carriers, are typhoid and paratyphoid fevers, cholera, diphtheria, cerebro-spinal meningitis, influenza, encephalitis lethargica, dysentery, pneumococcal infections, acute poliomyelitis, malaria and tuberculosis.

In some cases, "carriers" are really healthy as they do not show any clinical signs of the disease, but most of them are only apparently healthy, because, on careful examination, signs or symptoms of local infection can be found in them.

Carriers are usually classified as follows :—

(1) Precocious or incubation carriers. They are unable to exert much influence in the propagation of infections.

(2) Contact carriers, *i.e.*, persons who acquire the infection from association with cases or carriers, without developing the disease themselves.

(3) Convalescent carriers, who continue to harbour during convalescence the organisms which caused the illness.

(4) Chronic carriers, who harbour infective organisms for some length of time after recovery from the disease. In this class of carriers, the periods of infectivity are often only displayed intermittently, with intervening periods of non-infectivity. From the point of view of the sanitarian, it is these "chronic carriers" who are the most dangerous.

It is important to know that in the case of chronic carriers, there are certain parts of the body wherein the virulent organisms become embedded, which act as foci for the spread of the particular diseases. The two such sites, which are most important, are the tonsils and the gall-bladder. Chronic tonsillitis, along with an ulcerated patch in the mucous membrane of the nose or pharynx, will explain the existence of many carriers of virulent diphtheria bacilli and hæmolytic streptococci. A similar condition of the throat or nose is responsible for carriers of pneumococci, influenza bacilli, and meningococci. An inflamed gall-bladder acts as the habitat of rich cultures of typhoid and cholera bacilli. A person who has previously suffered from typhoid fever is very liable to intermittent attacks of biliary colic, and this liability would suggest the possibility that such a person was a chronic typhoid carrier. There are other lesions of intestinal carriers, such as chronic ulcers of the intestines, which are to be found in carriers of dysentery. Among certain typhoid carriers the lesion exists in the kidneys in the shape of chronic pyelitis with secondary cystitis. They are known as urinary typhoid carriers.

The problem of dealing with carriers, so as to prevent them from being a danger to others, is a very difficult one. A sick person will readily seek treatment, but a carrier who is apparently healthy, is most difficult to be convinced that he also needs medical attention. One of the most obvious measures would be to prevent cases from developing into carriers. But unfortunately we have no knowledge as to why the germs of certain specific diseases disappear in some persons immediately after their recovery, and why they persist in others. It is therefore practically impossible to devise measures for preventing individuals from developing into carriers.

In regard to patients who have suffered from typhoid fever, diphtheria, and other "carrier diseases", it is very desirable that they should be examined at short intervals to see if they are still harbouring the infection in the throat, nose, or pharynx, or discharging it in their fæces or urine. The methods employed for the isolation of the typhoid bacillus from the fæces are somewhat intricate and difficult to carry out, but its isolation from the urine is comparatively a very easy matter, as it is generally the only organism present in that secretion. It is therefore suggested that the routine examination of the urine of such carriers ought to be carried out, combined with a Widal test. It is stated by Kayser that about 75 per cent. of carriers respond to this test. Such routine examinations can be more easily carried out in hospitals and analogous institutions. It must however be remembered that this Widal test may prove unreliable in some cases, owing to the persons having had anti-typhoid vaccine inoculated into them as a preventive measure. In such cases the agglutination tests are obtained more easily. Similarly the routine examination of the excreta may also give negative results, because the bacilli are discharged intermittently.

Isolation of carriers is another very rational and obvious measure, but it is very impracticable, and is rendered more difficult by the continual occurrence of fresh contact carriers, and the periods of intermission to which some carriers are subject, during which no infective organisms can be detected in them. Moreover the enforcement of such a measure would require the provision of special beds for isolation and observation in hospitals.

Another method suggested for dealing with carriers, is to give them specific anti-microbic treatment by means of vaccines and sera. But generally speaking, these measures have proved disappointing. It has been found by experience that typhoid vaccination does not cure typhoid carriers, and in the case of diphtheria carriers, antitoxin exerts no effect on the persistence of the bacillus.

The local use of disinfectants particularly in throat infections has been found of some value in reducing the number of organisms, and thus lessening the danger of transmission. The method employed, particularly for the treatment of influenza and cerebro-spinal fever carriers, is to construct an inhalatorium, in which an automatic steam spray is used for charging the air of a room with a two per cent. solution of Chloramine—T, or a solution of sulphate of zinc. The air of a room charged with these disinfectants if inhaled for about twenty minutes at a time, has succeeded in rendering the nasal passages of such carriers, sterile. The internal use of certain urinary antiseptics has proved of value in the case of convalescent carriers of enteric fever, in whose urine, typhoid bacilli were found. But in the case of chronic typhoid carriers who harbour the germs in the intestines or gall-bladder, Metchnikoff's treatment by means of sour milk has given disappointing results. It is said that in the case of diphtheria carriers, the regular spraying of the nose and throat for several days with a pure culture of Staphylococcus Pyogenes Aureus has

been partially successful in eliminating the diphtheria germ. But it is dangerous to use the Staphylococcus for this purpose.

Many workers in Chemotherapy have experimented with various compound drugs particularly in the case of gall-bladder infections, but without much success. So far as our present knowledge goes, the only effective chemo-therapeutic remedy that has proved of value, is the bismuth-arsenic compound drugs in the case of spirochete carriers of venereal diseases. Emetin injections are of value in the case of chronic carriers of amœbic dysentery.

The removal by surgical operations of the various foci in carriers has given promising results. According to Dr. Henry J. Nichols the removal of the gall-bladder has been successful in over 50 per cent. of typhoid carriers, and the removal of tonsils and adenoids in 80 per cent. of diphtheria carriers. Radium and X-ray have been tried as a substitute for surgical operations, but the results have not proved satisfactory.

Lastly "in the handling of carriers, personal hygiene must be given a prominent place". It is essential that typhoid, cholera, and dysentery carriers should, on every occasion when the privy or urinal is visited, wash and cleanse their hands and nails with soap and water. They should not be engaged in the preparation and handling of food-stuffs. Special care in the disinfection of the dejecta of such persons is also necessary. In the dwellings occupied by them, privies and urinals must be systematically disinfected. Carrier cases should as far as possible be kept under observation, until they cease to be dangerous. In order to ascertain when this danger ceases, the sanitary authority should take occasional samples of both urine and fæces for bacteriological examination. It would also be a very desirable precautionary measure to examine the excreta of all cooks in institutions, and also of the workers in factories and workshops where certain kinds of food are prepared.

CONTROL OF INFECTIOUS DISEASES.

At an informal conference of Sanitary Commissioners held at Simla in May 1919, the following measures were recommended for the Control of Infectious Diseases :—

(1) Publication of correct vital statistics of larger towns in the provincial Gazettes and the modification of the form of weekly reports regarding the condition of health at principal ports ;

(2) Early notification of all infectious diseases ;

(3) Provision of properly qualified Medical Officers of Health for urban and rural areas ;

(4) Security of appointment of urban and rural M.O.H.;

(5) Institution of State Faculty of Public Health for each province ;

(6) Industrial hygiene in the prevention of industrial dust and the reduction of hours of labour ; demand for additional staff of Inspectors ;

(7) The hygienic education of the general public, inclusive of students and scholars ;

(8) Necessity of securing to the Sanitary Commissioner the position of responsible technical adviser to the Local Government in all matters affecting public health ;

(9) Establishment of a public health bureau for publishing a public health bulletin ;

(10) Training staff for employment in epidemic times ; the training to be confined to such primary matters as the disinfection of wells, treatment of cholera stools, rat trapping and baiting, etc.

(11) Prevention of the importation of Yellow Fever. The reduction of facilities for the breeding of Aëdes (stegomyia mosquitoes) in ports and legislation to enable ports to take action against the breeding of mosquitoes.

RULES FOR THE GUIDANCE OF INSPECTORS.

1. In dealing with epidemic diseases, such as Cholera and Small-pox, all other duties should be put aside, and *immediate* attention given to cases brought to the Inspector's notice.

2. When a case of Cholera is reported to the Conservancy Inspector, he shall at once arrange to disinfect the privies, traps and receptacles with Izal fluid, and clean and flush the gullies with Pesterine.

3. Gullies, where dead rats have been found, should be well cleaned and flushed and then pesterined.

4. During epidemic seasons, all boarding-houses, Goanesè clubs, *musafarkhanas* and *dharmashalas* shall be regularly visited and inspected by the Inspector or Section Sub-Inspector.

5. The following disinfectants shall be used :—

Pesterine or Kerosine oil emulsion for Plague-infected houses and where dead rats have been found ; also to prevent breeding of flies, &c., and in case of accumulations of water to prevent mosquito-breeding.

Izal Fluid for Small-pox, Cholera, Phthisis, Measles, etc., and mixed with Pesterine for Malaria as it has been found to be effective in killing larvæ.

Sulphur for fumigating after Small-pox, Measles, Phthisis, etc., and for vermin.

Izal powder for places where fluid cannot be used and for those fouled by human excreta and urine.

Permanganate of Potash for wells infected with Cholera vibrio.

Tuberculosis.

Sir William Osler defines "Tuberculosis" as "an infection caused by Bacillus Tuberculosis, the lesions of which are characterized by nodular bodies, tubercles and diffuse infiltrations which either undergo caseation, necrosis and ulceration, or heal with sclerosis and calcification."

The Tubercle bacillus discovered by Prof. Koch in 1882 is an organism capable of living, not only within, but also outside the animal body; it may be cultivated on various artificial media. A very favourable medium for its growth is the Dorset's egg medium. The other special media for primary growth are glycerinated potato, glycerinated serum and glycerine brain-agar. Like other organisms, it exhibits certain morphological characters, which may be observed by means of the microscope; it grows and multiplies in certain ways, and possesses certain physiological properties through which it acts upon and is acted upon by its environment, whether that environment be a living animal body or a lifeless artificial medium.

Tubercle bacilli, when stained with carbol-fuchsin, are seen to be delicate cylindrical pink rods, slightly curved or straight, with a granular appearance; they are "acid fast," that is, when stained and treated with acid, they retain the original stain.

Besides the human type there exist the bovine and the avian types of the bacillus. The bovine bacillus is shorter and thicker and less readily cultivated than the human bacillus. In staining and morphology the avian bacillus is similar to the bovine type but differs from it on cultivation and inoculation.

Tuberculosis occurs in many, if not all, of our domestic animals, *e.g.*, in the ox, pig, horse, sheep, cat, dog and others.

The principal form in which Tuberculosis affects man is "Pulmonary Tuberculosis," "Phthisis," or "Consumption,"

but all parts of the body may be affected as in Tabes Mesenterica, Tuberculous Meningitis, and Tuberculosis of the joints and organs.

Tuberculosis may be spread from man to man, by the inhalation of dust containing Tubercle bacilli, or by direct infection from the sputum, also by infected milk and meat and by flies.

At the British Congress on Tuberculosis in July 1901, Prof. Koch said that bovine and human Tuberculosis were different; that the former could not be transmitted to man except under exceptional conditions; and that precautions against bovine Tuberculosis were not necessary. This came as a thunder-clap to the medical world, and the result was a Royal Commission appointed in 1901: from the Report published, it has been shown that there is very little difference between the Tuberculosis of cattle and man, and that they can be transmitted from one to the other.

The Royal Commission state that the cases of Tuberculosis and the Tubercle bacilli found in the intestinal glands of children were similar to those of bovine Tuberculosis, and the disease was due to infection by food and milk.

There can be no doubt that in a certain number of cases Tuberculosis occurring in the human subject, especially in children, is the direct result of the introduction into the human body of the bacillus of bovine Tuberculosis, and that, in the majority at least of these cases, the bacillus is introduced through cow's milk. Cow's milk containing bovine Tubercle bacilli is clearly a cause of Tuberculosis and of fatal Tuberculosis in man.

A very considerable amount of disease and loss of life, especially among the young, must be attributed to the consumption of cow's milk containing Tubercle bacilli.

The Tubercle bacilli may be present in the milk of cows which are otherwise apparently healthy; they are found in large numbers in the fæces of infected cows.

Shröeder in an interesting paper states that 40 per cent. of the dairy cows, that retain the appearance of health and are not known to be affected till they are tested with tuberculin, actively expel Tubercle bacilli from their bodies in a way dangerous to the health of other animals and persons; that a considerable proportion of the dairy products is infected with Tubercle bacilli owing to the frequency with which cow fæces are found in milk: for it has been proved that the commonest way for Tubercle bacilli to pass from the bodies of Tuberculous cows is with their fæces, and once milk is contaminated with Tubercle bacilli, the latter enter the various articles of diet prepared from it, and are specially numerous in butter, in which they may remain alive seven weeks or longer without diminishing in virulence. The practical importance of this is that herds of Tuberculous cattle can be cleaned by the periodic application of the tuberculin test.

These results clearly point to the necessity of measures more stringent than those at present enforced, being taken to prevent the sale or consumption of milk of tuberculous cattle.

BOVINE AND HUMAN TUBERCULOSIS.

It is now definitely settled that Tuberculosis in cattle may and does cause Tuberculosis in man, and this is especially important with reference to the disease in children in India.

The interest taken in the cause and control of this disease in England, France, Germany, America, Australia and other countries of the world and the investigations undertaken by them have tended to reduce the incidence of the disease considerably; but in India little has been done to ascertain whether the conditions which obtain in other countries exist here, or how they may vary. It is generally assumed that bovine Tuberculosis is rare in India.

WORK DONE IN INDIA.

In considering the possibility of children in India contracting Tuberculosis, both general and pulmonary, from tuberculous cattle—either by milk or infected fæces and also by milk infected by human agencies—the following questions present themselves for solution :—

(i) Whether cows or buffaloes in India suffer from Tuberculosis.

(ii) Whether milk could be infected by human or bovine agencies, after it had been drawn from a healthy animal,—by the habits and customs of the attendants, and by infected fæces.

(iii) Whether the human being, especially children, could not contract Tuberculosis, because of the intimate relation of the working classes with cows, bullocks and buffaloes, and the enormous use made of cow dung, some of which must be infected.

To ascertain the truth, the examination of samples of milk and human sputa from milk shops and milch cattle stables in the City was undertaken in Bombay at the Municipal Laboratory by Dr. Ghadially and Dr. Joshi.

The milk was collected from different milk shops, by the Deputy Health Officers of the Wards, in sterile glass bottles and sent to the Laboratory. 20 c.c. of each sample were centrifuged and the sediment examined, and if acid fast bacilli resembling Tubercle bacilli were found, the Deputy Health Officer was asked to trace the source of milk. This was not easy, as the milk sold at the retail shop was mixed. Only in 6 cases could the infected milk be traced to cows. Milk of these cows was then drawn into sterile glass bottles and again examined and a positive result obtained in the case of all the six cows.

Tuberculin test.—The animal is first allowed to become cool and quiet; then the temperature is taken per rectum the thermometer being allowed to remain in for 5 minutes.

The *normal temperature of bovine animals is from* 100·5° to 102·5° F. It is convenient to inject the tuberculin into the neck or shoulder late in the evening, so that the observation of the reaction temperature may be made early next day. The animal should not be regarded as positively tuberculous unless the morning temperature exceeds the previous night reading by at least 2·5° F.

The test should not be repeated until at least a month has expired.

All the six cows were treated with tuberculin: four of them reacted 2·5° and two only ·7°. Milk from the former four cows was injected sub-cutaneously into guinea-pigs with no result.

In all 217 samples of milk were examined, of which 9 were repetitions; thus out of 208 examined, an acid fast bacillus was found in 30 or 14·4 per cent.; of these, 9 were traced to cows; these were tested with tuberculin and 6 reacted.

A *post-mortem* examination could not be made. Much difficulty was experienced in getting permission even for testing with tuberculin.

In all, 105 cows and buffaloes were tested with tuberculin:—

34 at Bandra Slaughter House—none reacted;

5 buffaloes and 31 cows at Panjrapole—2 cows reacted;

26 cows privately—3 reacted—no *post-mortem*;

9 buffaloes privately—no reaction.

The fæces of the two cows reacting to tuberculin were examined and found to contain an acid fast bacillus of the same type as in milk.

On *post-mortem* examination of these cows, no Tubercle bacilli could be found in any of the organs, but cystic degeneration and cysts were plentiful.

To find Tubercle bacilli in milk, unless the animal is suffering from acute Tuberculosis of the udder, is difficult and requires care; other acid fast bacilli may be present, and to differentiate, the infected milk must be inoculated into a guinea-pig. This, however, is not always decisive, as milk may contain very few bacilli and then no reaction takes place.

This process was followed on nine occasions with no result. The tuberculin test, when followed by a high and maintained rise of temperature, is considered sufficient evidence of tubercle in cattle, which can be verified by a *post-mortem* examination. Unfortunately, it could be carried out only on two occasions—with a negative result.

The other three cows reacting to tuberculin lived and calved thereafter; on re-inoculating them 3 months later, no reaction occurred.

In 30 cows selected at Bandra Slaughter House as looking suspicious of Tuberculosis, Tubercle bacilli were found only in the organs of one. The acid fast bacillus found in the milk was not Tubercle.

Samples of human sputa collected from bathing places, washing places for cows and buffaloes, and from milk shops and the streets were examined for Tubercle bacilli.

Out of 271 such samples examined, 33 or 12 per cent contained Tubercle bacilli: the object in examining the sputa was to ascertain, if possible, whether the milk could be infected in that way.

An outbreak of Tuberculosis occurred amongst spotted deer and Llamas at the Victoria Gardens, Bombay. *Post-mortem* examination revealed the presence of tubercle pathologically and bacteriologically. Many of the animals had been bred in confinement and others had been introduced from Europe and India.

MILCH CATTLE STABLES AND ATTENDANT EVILS.

Anyone with any experience of milch cattle stables, dairies and milk shops in India, and the habits and customs

of the *gowlies*, their methods of milking and of washing themselves and their milk vessels, can easily appreciate that milk could be infected in this way, and that possibly the samples examined may have become infected by human agency and not bovine. The results of the tuberculin test and *post-mortem* examination of the cows tested, however, showed that this could not be the only source of infection. The results of the Royal Commission, moreover, prove clearly that the fæces of the tuberculous cow are loaded with Tubercle bacilli, and a visit to a milch cattle stable in Bombay will readily show how this may be a possible means of infecting milk.

The report of the Haffkine Institute for the year 1929 gives interesting information under the heading of "Tuberculosis Inquiry" conducted at the Institute by Dr. Soparkar and his assistants. The conclusion drawn from their study of the type of bacilli causing Surgical forms of Tuberculosis in India is as follows: "The bovine tubercle bacillus plays a negligible part in the causation of Surgical forms of tuberculosis in this part of India" (Bombay Presidency). However a different picture is obtained from the Punjab side where recent investigations have shown that the chances of infection from the bovine bacillus are proportionately much greater.

FACILITIES FOR TRANSMISSION OF TUBERCLE BACILLI.

The milk-vessels are cleaned with cow-dung and dirt. The buffaloes and cows wallow in their excrement, and they are washed at the same place where the milk vessels are cleaned and with the same water. This, then, is a common way of infecting milk and is peculiar to India; because in England and Europe, the value of the cleanliness of the cow and the utensils is much more appreciated, and the regulations concerning the milk supply are much more strict. Although the buffalo is washed regularly in some stables in India, its surroundings and the habits of its attendants are much more insanitary.

Again, the traffic in cow-dung is enormous. Cow-dung mixed with urine and mud is used for plastering walls and floors and roofs of houses.

Even in large cities, the cow and bullock are inmates of the dwelling house, and all the cooking pots and vessels used are scoured with cow-dung and dirt from the street.

The facilities then for the transmission of the Tubercle bacilli from animal to man are greater in India, because of the intimate connection between them.

Fortunately, the climate has some influence on the life of the bacilli, and the exposure to the heat of the sun checks the growth; but the dust of the streets, where there is so much of bullock traffic, must contain a large number of Tubercle bacilli, while flies and dust must convey the infection to food and milk.

Again, it is a very common sight to see crows eating sputum in the streets or stables; to see crows, after picking up sputum fly to a milk or water vessel and dip in their beak, or pick the meat and fish in the market, or from the open basket on the head of a cooly, or drink milk out of milk vessels in the stables or open cans in the streets or shops.

RESULTS OF INVESTIGATION IN BOMBAY.

The results of the investigation are (*i*) that cattle in Bombay, and presumably other parts of India, do suffer from Tuberculosis to a slight extent; (*ii*) that it is possible for milk to be infected by human agency owing to the habits and customs of the attendants and the methods of distributing milk; (*iii*) that a possible source of infection is the fæces of infected cattle—due to the intimate connection between the labouring class and the cattle and the enormous use made of cow-dung in the houses and surroundings.

It is not meant to suggest that Tuberculosis in India is caused only by infected milk or food; but that it is one cause which has hitherto not been investigated. Nor it is

maintained that the experiments carried out cover the whole ground, or are complete, or free from the possibility of error, but with the pressure of other work in a very large and busy Department, complete research cannot be undertaken; they are, however, sufficient to warrant further inquiry and more stringent regulations regarding the milk and food supplies in India.

Statistics show that the mortality from Tuberculosis is higher in India than in England; the milk and sputa examined show that there is risk of disseminating the Tubercle bacillus while the presence of this bacillus in the fæces of infected animals is a greater danger in India than in other countries. The argument that all milk is boiled before being used is applicable to any milk-borne disease; but the majority of people would prefer to know that the milk comes from healthy animals and is pure.

Sanitation and education in sanitation and the application of sanitary laws and regulations, and sanitary surroundings are of great importance in Tuberculosis as in Malaria and Plague and all other communicable diseases. Every preventive measure should be availed of and all milk should be boiled.

TUBERCULOUS DISEASE IN CHILDREN.

The Medical Research Council has published an interesting account of the investigations carried out by Dr. John W. S. Blacklock on the pathology and bacteriology of tuberculous disease in children. These investigations were based on a study of infants and children from a few hours old up to 13 years of age, dying in the Royal Hospital for Sick children, Glasgow, either from illness of any kind or as the result of accident, over a period of 7 years and 8 months (March 1924 to November 1931). A careful search for any evidence of tuberculous disease was made in 1800 antopsies. Naked eye evidence of tuberculous infection was obtained in 283 cases (15.7 per cent.). Of these 90 per cent. died as the result of

infection. The site of Primary damage was located as follows :—

Chest=61.1 per cent.

Abdomen=35.7 per cent.

Cervical glands=2.1 per cent.

In 183 cases with definite tuberculous damage the infective organisms were isolated and typed. In 52 cases of surgical tuberculosis of which none died in the Hospital—similar procedure was followed.

Dr. Blacklock, on the strength of his careful investigations concludes that the pathway of infection in children—who died from tuberculosis and in whom the primary infection was located in the lung—has been by the air. Further the type of bacilli in these cases has been of the human type.

Dr. Blacklock's findings—as far as they concern the West of Scotland alone—are definitely opposed to the general view that active pulmonary tuberculosis in the adult is the result of the flaring up of dormant infection received in childhood. According to his investigations (as confined to the locality mentioned) the adult infection is a new infection contracted in later life and differs from that in childhood both in pathology and site.

The investigation of cases with primary abdominal lesions has once again proved the importance of protection from bovine infection in children.

The significance of tuberculin reactions in children has also been investigated by Dr. Blacklock and so far as his findings go they support Hart's statement that in the infant a positive tuberculin reaction must be regarded as a grave prognostic sign.

THE ETIOLOGY OF TUBERCULOSIS.

The etiology of Tuberculosis in Bombay is one of the most complex problems: poverty, ignorance, and neglect,

the social customs and habits of the people and the overcrowded and insanitary conditions at home ensuring to a great extent the progress of the disease.

Overcrowding is one of the principal causes contributing to the spread of Tuberculosis. It tends to increase the opportunities for personal contact and infection, to hinder the possibility of free ventilation, and to lower the vitality and power of resistance of the people. The mere statement of the average number of persons per acre in a town is often misguiding. Much depends on the number of persons residing in each room. By careful planning of the houses erected, it is possible to accommodate a larger number of people in a certain area without overcrowding. In Bombay, about 80% of the population dwell in one-room tenements. The evils resulting from overcrowding are far greater in the northern parts of India than the southern, as in the former the intense cold induces the people to shut themselves up closely in their houses, and thereby greatly hinders free ventilation.

Tuberculosis is both the parent and child of poverty. Certain people, through pecuniary difficulties, due to unemployment are forced to curtail expenses and live in insanitary quarters where the conditions are such as to easily open the way to Tubercle. The tuberculous, on the other hand, rendered helpless by the enormous financial drain involved by the disease for treatment, extra food, etc., and inability to work, are compelled to shift to cheaper rooms in insanitary localities.

Certain social customs among women in India are a potent factor in the causation of this disease and account for the fact that in many cities of India more than twice as many women as men suffer from Tuberculosis. The "purdah" system amongst the Mohamedans is directly responsible for the large incidence of the disease amongst the females of that community. The women are generally secluded in one of the hind

rooms, which is not a very sanitary part of the house, with no attempt to ensure fresh air and light.

In public these women use a veil or "boorkha," which is a white cotton garment which completely covers the body and face. Since more than one member of a family often use the same "boorkha", the serious danger of infection resulting from this practice will be realised, especially when some members of the family are already suffering from Phthisis. The incidence of the disease is greater in those cities where the purdah system is followed either amongst Hindus or Mussalmans.

The annual report of the Anti-tuberculosis Department of the Bombay Municipality for the year 1930 gives interesting figures showing the incidence of tuberculosis in both sexes of the two main communities—(Hindus and Mohamedans)—in Bombay.

	Male.	Female.
Hindu	61·15 per cent.	38·42 per cent.
Mahomedan ..	38·85 ,,	61·58 ,,

The following remarks are quoted from the same report: "It appears from the above figures that Hindu males are physically inferior to, or in other words, have lower powers of resistance than the Mahomedan males; whereas the Mahomedan women are more readily susceptible than the Hindu women. Further taking the Mahomedan community alone, it appears that the women are much more susceptible than men. The natural inference is that the zenana system amongst the poorer Mahomedan classes on account of its insanitary accompaniments (*i.e.*, want of fresh air and sunshine) undermines their constitution to such an extent that they become more readily susceptible than their own sex in the Hindu community and their opposite sex in their own community." Of the tuberculous cases amongst all the females treated at the Bombay Municipal Anti-tuberculosis Dispensaries the Mahomedan women top the list with 52·86 per cent.

The early marriage system, the sexual excess at premature age, and the crude methods adopted in the management of child-births are some of the causes which produce considerable mental depression and physical strain on the young girls during the early days of married life, and thus open the door to the Tubercle bacillus.

The habit of indiscriminate spitting is largely conducive in India to the spread of Tuberculosis. The Tubercle bacillus thrives and retains its vitality for a long time in dirt in the absence of fresh air and sunlight. It has been found that Tubercle bacilli in sputum, when exposed to direct sunlight die after 8 hours, and to diffused day-light in 8 days, but when kept in darkness they are alive and virulent even after 309 days. A careless consumptive who is passing millions of Tubercle bacilli in his sputum would be a great menace, therefore, if he were to spit indiscriminately on the floor and walls of his room, the spit would dry up and be distributed in the dust and any person inhaling the vitiated air, specially if his vitality has been already lowered, will fall a victim to the disease. The practice amongst the poor of wiping their mouth with the end of their garment, or the lappet of the shirt is objectionable and attended with risks of infection. At home the people should spit into a spittoon or into an open vessel containing some disinfectant like carbolic lotion (1 in 20) or izal (1 in 50). A tray containing ashes or bits of rags or paper contained in a receptacle will do, provided it is emptied from time to time into the fire. For outdoor use, a pocket flask spittoon is advisable.

TRADES AND OCCUPATIONS.

There are several occupations which levy a high toll. In India, however, there are not so many industrial occupations as in England in which vitiated dust is inhaled and in which labourers are exposed to great variations of temperature and pressure. Moreover, most of the Indian labourers work less in crowded workshops, but more in the open air and in private houses, depending more on hand power than on machinery.

There are several occupations carried on in small ill-ventilated rooms for long hours at a stretch which necessitate the workmen sitting down in a recumbent position for a long time and which levy a large toll. Tailors, shoemakers, clerks, shop-servants and weavers suffer very frequently. Special reference must be made to the "bidi" makers (cigarette makers) in Kamatipura in Bombay before this trade was controlled by licenses. The workers, chiefly women, were crowded together in dark ill-ventilated hovels for several hours in making bidis. They spat promiscuously on the floor and unwittingly helped in the disease being conveyed from one to the other. An idea of the overcrowding and unhealthiness in the bidi shops could be had from the fact that 20 to 30 women were usually huddled together in a small room in which there was no fresh air and sun-light and which abutted on foul smelling passages. If one of these workers has already contracted the disease, the chances of spreading infection are very great.

There are certain industries which involve the constant breathing of air charged with irritating particles and in which the workers suffer to a large extent from Tuberculosis. These are cotton ginning mills, jute factories, rice cleaning mills, quartz crushing mills, coal mines and the like.

Distribution of Tuberculosis in India.

It is difficult to gauge the magnitude of the evil caused by Tuberculosis on account of the unreliableness of the little information that is available. The vital statistics in India are inevitably very inaccurate, as the verification of cause of death is done by ignorant "chowkidars" even in many of the larger cities. Moreover, in the Report of the Sanitary Commissioner of India, Phthisis is not classified under a separate heading, but is included under respiratory diseases, many of the deaths from Tuberculosis being registered under "Fevers" and "All Causes." The Tuberculous death-rates of the cities of India are, therefore, not sufficiently accurate.

Classification of Indian Cities, according to estimated prevalence of Tuberculosis (from Lankester).

CLASS I. Death-rates less than 2.0 per Mille.	CLASS II. Death-rates from 2.0 to 3.0 per Mille.	CLASS III. Death-rates over 3.0 per Mille.
Aligarh, Allahabad, Amroati, Aurangabad, Berhampur, Cuttack, Ellore, Ferozpore, Gorakpore, Jalna, Kohat, Syallpur, Muttra, Montgomery, Muzaffarpur, Nainital, Nowshera, Pakhoku, Ranchi, Rawalpindi, Saigang, Salem, Shillong, Simla, Taru-Taran, Vellore, Waltair, Warangal, Wardha.	Ahmednagar, Bangalore, Bannu, Bareilly, Bhagalpore, Bharatpur, Gwalior, Indore, Jabbalpur, Jhansi, Jodpur, Karachi, Ludhiana, Moradabad, Moulmein, Meerut, Mysore, Nagpur, Patiala, Prome, Puri, Secunderabad, Sialkote, Tanjore, Tinnevelly, Trichinopoly, Udaipur, Vizagapatam, Wazirabad.	Agra, Ahmedabad, Ajmere, Amritsar, Benares, Bhopal, Bombay, Broach, Calcutta, Calicut, Cawnpore, Dacca, Delhi, Gaya, Hyderabad (Sind), Hyderabad (Deccan), Jaipur, Lahore, Lucknow, Madras, Madura, Mandalay, Multan, Patna, Peshawar, Poona, Rangoon, Srinagar, Surat.

The distribution of Tuberculosis in India is dependent upon the varying climatic conditions of the country and the social customs of the people. Dr. Lankester in his book on "Tuberculosis in India" says that the plateaux of India with (except during the monsoon) their small rainfall, low relative humidity, dry clear atmosphere and high mean temperature are the most favourable regions, Tuberculosis being the least prevalent. Thus the high table-lands of Rajputana, Central India, the Central Provinces, the Deccan, and Mysore plain are very favourable in comparison with other parts of India, both as regards the low prevalence of Tuberculosis, and as to the effect of their climate, in the treatment of sufferers from the disease.

Dr. Lankester places the following areas as more or less intermediate as regards the prevalence of the disease. The Sindh desert, the south-western portion of the Punjab,

the north-east corner of the United Provinces around Gorakhpur, with the adjacent parts of Bihar, north of the Ganges; the whole of Orissa and the whole of the Madras Presidency with the exception of the Malabar coast and the southern hills.

The remaining parts of India appear to be most unfavourable, Tuberculosis being very prevalent. These comprise the delta of Bengal, the eastern and western Indo-Gangetic plain including the whole of the Punjab except the south-western corner; the valleys of the North-Western Frontier Province and lastly Gujarat and the western littoral, and the Malabar coast.

The mortality from Tuberculous diseases is very much greater in cities than in villages; the villages on the outskirts of the city suffering more than those more distantly situated.

The migration of people from villages into the city for employment specially during the times of famine, and the increased facilities of communication afforded by the network of railways in India have been largely conducive to the increase of Tuberculosis in Indian cities. On the other hand, people contracting Tuberculosis in the cities go over to the villages and carry and spread infection there.

The social factors are even more important than the climatic in deciding the incidence of Tuberculosis, as in certain cities, *e.g.*, Agra and Hyderabad, the prevalance of the disease is very great, being over 3 per mille. But such cities though unfavourable as regards incidence are very favourable for the treatment of Tuberculosis on account of the climatic conditions. It has been the experience that people emigrating from places where the incidence of Tuberculosis is very low or negligible into cities which are the hot-beds of the disease easily fall victims as they are not sufficiently immune. Thus, for instance, the Gurkhas and Pathans who come from the hilly regions in the north of

India, where Tuberculosis is practically absent, are very susceptible to the disease when they migrate into the large cities of India.

PRACTICAL PRECAUTIONS AND MEASURES.

To undertake thoroughly the work of controlling and exterminating Tuberculosis in a community, much time, trouble and energy are required, with a perfect organization and thorough control, and suitable by-laws and regulations, To attain any measure of success, however, the Medical profession, the public, the Sanitary and Municipal Authorities and the Government must co-operate. The various measures may be classified as follows:—

1. Compulsory notification.
2. Tuberculosis dispensaries.
3. Sanatoria and village colonies.
4. Hospital for advanced cases.
5. General sanitary measures including the house problem.
6. Open air schools.
7. Special preventive measures.
8. Educational measures.
9. Food control.

COMPULSORY NOTIFICATION.

The advantage of a compulsory system of notification is not merely to enable the removal to a Hospital of the cases that come under observation and to disinfect their homes, but also to ensure that the hitherto unrecognized cases are detected and insanitary conditions in domestic and industrial life are discovered and removed. The success of compulsory notification depends on the amount of medical relief that is available. A sufficient staff of skilled health visitors for

giving instructions, and an adequate provision of beds for advanced cases, and accommodation in sanatoria for early ones will be required. Medical inspection of factories, workshops and infected houses should be made, regular forms should be kept, and a register made of all cases visited and action taken. Early notification :—On receipt of a notification or information of a case or of a certificate of death from Phthisis, or as the result of examination of sputum sent to the Laboratory, the Sanitary Officer should visit the house, making inquiries into the duration of the case and its surroundings. Instructions should be given, printed and oral, and the case, if possible, removed to the Hospital for Consumptives. He should then proceed to disinfect the room and bedding. The Esmarch process of rubbing the walls, ceiling, and floors with dough to collect the infected dust might be adopted in suitable houses, as it would not be practicable in all Indian dwellings ; the dough should afterwards be burnt. On no account should the room be swept with a brush or duster, as the infected material may be dispersed in the air and inhaled by the operatives.

Formalin spray or 2 per cent. solution of chloride of lime or izal (1–30) may be used for washing the floor, walls and ceilings. The furniture should be washed with a damp cloth soaked in izal. The linen and bedding should be passed through a steam sterilizer. A room occupied by a Phthisical patient should be thus treated frequently.

TUBERCULOSIS DISPENSARY.

The "Tuberculosis dispensary", which has come to be recognised as an important factor in an Anti-Tuberculosis campaign, owes its initiation to Sir R. W. Phillips who opened the first of its kind in Edinburgh in 1900. Since then, several hundreds of such have been opened up on the same lines all over the world. His idea that no one method of dealing with the disease could be effective in combating every aspect of the problem, culminated in the growth of the dispensary which

was destined by him to be a centre of co-ordinating all the various agencies endeavouring to fight the disease. In general the functions of the Tuberculosis dispensary are to serve as a :—

1. Receiving house and centre of diagnosis.
2. Clearing house and centre of observation.
3. Centre of curative treatment.
4. Centre for the search of incipient cases.
5. Centre of after-care.
6. Information bureau and educational centre.

The dispensary is not merely one in the usual sense of the word, but a great "clearing house" where various types of the disease are sorted out and sent to the various institutions most suited to the particular stage of the disease. Thus the medical officer has to be in close touch with the private practitioners, and the directors of numerous institutions affording treatment, *e.g.*, Sanatoria, Hospitals, Open Air Schools, etc. The staff usually consists of a medical officer with nurses and health visitors whose duty is to pay domiciliary visits to the patients attending the dispensary with a view to instructing them in elementary sanitation and finding out early cases. The King George V Anti-Tuberculosis League Dispensary at Bombay, now under Municipal control, opened in 1912, was the first of its kind in India and has served as a model for similar dispensaries opened up in many of the larger cities and towns of India. In large towns of India it would be advisable to have independent Tuberculosis dispensaries, one for every 100,000 people, and they should be so situated as to be easily accessible to the working classes.

SANATORIA.

The sanatorium serves as a curative and prophylactic measure of great importance. Modern experience has pressed

for the necessity of providing for every community sanatoria in which early cases can be treated and cured by removing them from the haunts of infection to suitable situations where their life can be regulated under medical control. From an educational point of view, it serves to impress upon the patient and his relations the nature of the disease and its mode of spread so as to enable them to continue the same care on his return home.

Whilst admitting of easy administration, the structure and surroundings should be inexpensive, yet hygienically as perfect as possible, and so built as to command the maximum of fresh air and sunlight. The question of locality and site has several inherent difficulties. In India it is preferable to establish sanatoria on the plains rather than at some hill stations. The plains have a number of advantages in India which are of great importance in deciding their value. They are easily accessible to the poor and, as the climate would conform more or less with that in their own country, it would be possible for the patient to safely return to his home without in any way feeling any change. A trip to the hills entails much expense and thus the poor are debarred from going to such places. The site should be healthy and within the reach of the district it is intended to serve, the ideal position being a place 2 or 3 miles from a railway station. The principal desiderata in judging the value of a place are a southerly aspect, low rainfall, protection from sun and wind, and free circulation of air round the sanatorium. Ample water supply without great expense is essential. The soil should be dry and porous with extensive lands round about planted preferably with pine trees. Amongst the other needs are freedom from heavy rains and dust, and ample space for further development. The amount of accommodation required for sanatorium treatment is estimated by the Departmental Committee on Tuberculosis as one bed for every 5,000 inhabitants in addition to hospital beds for advanced cases. They also recommend that the sanatorium should

not contain fewer than 100 beds. Amongst the principal sanatoria in India may be mentioned :—

1. Turner Sanatorium, Parel, Bombay.
2. Bahadurji's Sanatorium at Deolali.
3. King Edward Sanatorium at Bhowali (Kumaon Hills).
4. Bel-Air Sanatorium at Panchgani.
5. King Edward VII Sanatorium at Dharampur.
6. Mission Sanatorium at Almora and Madanpalli.
7. Hindu Sanatorium at Karla.
8. Wanless Tuberculosis Sanatorium at Miraj.

The Departmental Committee have divided cases of Pulmonary Tuberculosis into six classes :—

(1) Cases in which the disease can be diagnosed or is strongly suspected, but in which there is no evident impairment of the working capacity.

(2) Cases of recent onset, with some impairment of the working capacity, but without marked evidence of ill-health.

(3) Cases of recent onset, with evidence of acute illness.

(4) Cases of a longer history of illness. In some of these cases permanent arrest of the disease may be hoped for, but in the majority, restoration to full working capacity for more than a short period is not to be expected.

(5) Cases in which there is a permanent loss of working capacity. Many of these patients live for a considerable period in a condition of chronic ill-health.

(6) Cases in which a fatal termination within six months is probable.

Treatment in sanatoria will be chiefly necessary for cases falling within classes 2, 3 and 4, and for a small proportion of cases within classes 1 and 5.

VILLAGE COLONIES.

The establishment of open air colonies in Europe has been considered necessary to prevent a relapse in the large proportion of those who though discharged as "arrested" from the sanatorium have had to return to their insanitary homes and dusty occupations. Muthu has recommended for India a system of village colonies where consumptives can go to with their families and live an open air life and at the same time engage themselves in some occupations like gardening, small industries, carpentering, etc. Such colonies would be model villages possessing many activities and becoming a centre of education and training. If successful, they could be self-supporting or at least partly so. The persons fit for transfer to the colonies should be those free from constitutional taint, with no rise of temperature, and with arrested local manifestations. Such persons could easily work for three to four hours a day and produce work which could make the colonies self-supporting. For various reasons village colonies if adopted in India should thrive, land being easily available. The colonies should consist of groups of cottages with large gardens and containing accommodation for a hospital, sanatorium, school for children, farm, dairy, laundry, etc.

HOSPITAL FOR ADVANCED CASES.

The far advanced cases constitute the greatest source of infection and unless these are segregated, the chances of spread of the disease are multiplied. Hospital accommodation should be provided by the State, or Municipality or charitable persons. The open cases of Phthisis pass millions of Tubercle bacilli in their sputum. The careless habit of such patients of spitting indiscriminately and the personal contact at home with relations and friends greatly increase the risk of spreading infection. The most practical way in which medical relief could be afforded to the poor is by the creation of separate Tuberculosis wards, where those who are

lower down in the scale of life and who would be a source of infection at home could be nursed and be treated free of charge. Open air shelter, lean-to shelter, consisting of a verandah, could be added to almost any hospital.

GENERAL SANITARY METHODS.

This part of the subject has a wide scope, for it includes the laying out of streets, the provision of improved roads of communication, the construction of dwellings and workshops so as to ensure sufficient air-space, free ventilation, and abundant sun-light, the cleansing of streets and alleys, the avoidance of dampness, the removal of filth and dust, etc. The provision of more suitable houses for living than what the people possess and a domestic condition in which the physical health, the morals as well as the social conditions can be improved is the pressing need of the day. It has often been expressed and quite rightly too that the true solution of the Tuberculosis problem lies in the opening up of broad roads and so ensuring abundant air, light and ventilation in each and every room of the building. The question, therefore, of improving congested and insanitary areas by a systematic town planning, and of granting extended powers to local authorities to deal with such areas is one which merits the earnest consideration of Government. The building by-laws regulating the open space round houses and floor space require revision in most cities.

OPEN AIR SCHOOLS.

A large part of the work of prevention of Tuberculosis can be most effectively carried out through the school.

The Government of Bombay in a Resolution have intimated the necessity of :—

(*a*) Giving definite instructions in the schools in large towns on the dangers of Tuberculosis.

(*b*) The establishment of special classes for tuberculous children who should be segregated from their fellows.

(c) The opening of open air schools for children who are in a poor condition and likely to become tuberculous.

In India where the exigencies of the climate, except perhaps during the monsoon, are not such as to prevent the holding of classes in the open air, the need of such open air schools is all the more felt. A regular and systematic medical inspection of school children and school premises should be carried out by medical men and health visitors at the instance of Government or Municipality. Many students and some school teachers in various educational institutions suffer from Phthisis and are therefore a great menace to the innumerable children that come in contact with them. Children in boarding schools, orphanages and foundling homes are largely prone to the disease. Great care has to be taken in the planning of school buildings, so as to provide the maximum of fresh air and sunlight in the dormitories and school rooms, and great discretion has to be exercised in framing the school dietary and the curriculum of the students.

Open air schools should be established on the outskirts of the town. Such schools should have a nice garden, play-field, large dining room, resting sheds and baths. The services of a medical officer, a trained school nurse, and a dentist are necessary. The duration of the stay should at least be six months. The following are some of the suitable cases for such schools :—

(1) Children with tuberculous glands in the neck.
(2) Nervous and highly strung children.
(3) Children convalescing after serious illnesses.
(4) Anæmic and rickety children.
(5) Delicate children living in the same house as a notified consumptive.

SPECIAL SANITARY MEASURES.

The phthisical patient must be taught not to spit promiscuously on the floor and walls or in the streets and foot-paths.

Notices as to dangers of spitting should be widely circulated in all public places, workshops, factories, railways, tram-cars, etc. A consumptive should be instructed to always spit into a vessel containing a disinfectant or into a pocket glass which can be cleansed or into a paper spittoon which can be burnt. Phthisical patients should use their own spoons, forks, cups, glasses, etc. They should not sleep together with others. They should hold a handkerchief to the mouth whilst coughing or sneezing, and they should avoid kissing children. No dust should be allowed on the floors, walls, etc., and the latter should therefore be cleaned from time to time with a damp cloth. Free ventilation is of the greatest importance for the health of the patients and unaffected members of the family, and therefore the windows should always be kept open.

EDUCATIONAL MEASURES.

Education of the people and most specially of the children of to-day must be co-ordinated with the efforts of sanitary authorities to improve the surroundings of dwellings. The Bombay Sanitary Association has done much useful work in this direction by organizing several public lectures in institutions and schools, by cinematographic shows and by publishing several leaflets, posters and literature on the subject for the benefit of laymen.

MEASURES FOR THE PROTECTION OF FOOD.

Inspection of meat and milk, dairies, cow-sheds and slaughter houses should be systematically carried out. All milch cattle should be tested with tuberculin and such as react to the test should be removed. Legislation should be adopted for compensation and slaughter of infected animals. All infected animals should be cast away and destroyed. Complete control of the milk supply by the State is necessary ensuring the removal of dairies from centres of large towns and cities, cleanliness in the collection of milk and the transmission of it from the dairy to the consumer. The indifference of the

average Indian to protect his food from the invasion of flies may lead to the contamination of milk or any other foodstuffs in more ways than one.

Mention must also be made of B. C. G. Immunization of Infants.

The aim of Professor A. Calmette of Paris and of his Veterinary colleague, C. Guerin has been to secure immunity against tuberculosis by the inoculation with a Vaccine containing avirulent living tubercle bacilli. By 230 passages on a highly alkaline lipoid containing culture medium prepared with ox-bile, a strain of tubercle bacilli has been obtained which is said to be harmless on inoculation and followed by immunity. This strain is *now known as Bacillus Calmette-Guerin or B. C. G. Professor Calmett* strongly advocates the adoption of B. C. G. Vaccination in infants in all countries as a social measure against tuberculosis. In France 336,000 children had been inoculated upto May 1st, 1931. Although Professor Calmette and his colleagues and some of the wellknown continental authorities have spoken highly of the B. C. G. Vaccination, yet it has not received universal support, particularly amongst the English Physicians. The British Medical Journal of 20th June 1931, in its leading article entitled, "The value of B. C. G. Vaccination" states as follows :—

" Professor Calmette has failed by his animal experiments to convince the bacteriologists and by his human experiments to convince the statisticians. His logic is excellent, but his premisses are unproven. Not until he or other workers can bring more convincing evidence in favour of his particular method of Vaccination is there likely to be any general movement to adopt his methods in this Country."

MEASURES CARRIED OUT IN BOMBAY.

Leaflets in English and vernaculars are freely circulated and lectures delivered and notices against spitting issued to all schools and public places.

Cases of Phthisis are notified to the Health Officer, and the houses are disinfected and lime-washed; 1,629 cases were notified and 266 houses disinfected on account of the disease in 1932.

The Bombay Municipality has under its control two anti-tuberculosis dispensaries, one Sanatorium and a hospital for the advanced. The sanatorium is situated in the north of the island on a small hillock with extensive open grounds, and has accommodation for 32 patients in early stage of the disease. The hospital for advanced cases has 80 beds.

The Municipal campaign against tuberculosis in Bombay includes the following important measures :—

(1) Compulsory Notification of the disease.

(2) Tuberculosis Dispensaries—two.

(3) Sanatorium with 32 beds for early cases of tuberculosis.
(4) Tuberculosis Hospital for advanced cases with 80 beds.
(5) Surgical cases requiring operative treatment accommodated at the Municipal General Hospital—King Edward Memorial Hospital.
(6) Medical Inspection of school children.
(7) Supervision of milk and food supplies.
(8) Special allowance for the support of the family of necessitous patients.
(9) Examination of contacts at the dispensaries.
(10) Educational propaganda in co-operation with the Bombay Sanitary Association and also by house to house visiting by qualified nurses attached to the dispensaries.

Plague.

The first epidemic of Plague in India was noticed in Bombay in August, 1896. In spite of all attempts to prevent it, it spread all over the island, and from the island to the mainland. The disease may be said to have become indigenous in Bombay from 1897.

In 1898 a Plague Commission was appointed to inquire into the cause, &c., of the disease. The Commission spent four months in India and returned to England, and in 1901 issued a report on their investigations. Evidence was taken from every one in India who was considered to have had any experience of the disease. In addition to this Commission, deputations were sent from Austria, Germany, France, Russia, Turkey and other countries to investigate the disease. The inquiries have all been published and comprise much that is of value. But the actual results of this Commission, so far as controlling the disease or throwing any light on its origin, its method of infection and measures to prevent its spread in India are concerned, have been practically nil, as evidenced by the virulence of the disease during succeeding years in India.

The Plague Research Commission, appointed in 1905 published from time to time the results of their investigations giving new and interesting material bearing on the subject.

Introduction into Bombay.

How the disease was brought to Bombay in the first instance is still unascertained. Several theories have been advanced, the most important being as follows :—

(1) The disease may have been brought to Bombay by sea from Hongkong or from the infected parts in Southern China.

(2) It may have been conveyed from the Persian Gulf, the disease being endemic in Mesopotamia.

(3) The infection may have been carried from Kumaon and Garhwal Hills to Bombay by pilgrims.

(4) Another theory is that it was brought by pilgrims from Jeddah. It has been suggested that the infection may have been carried by rats, merchandise, infected clothing, food and grain.

N. B.—A reference to the map of southern China, India and Arabia will be of interest with regard to the theories suggested. It will be seen that in August, 1896, Plague first appeared in Bombay after an interval of 200 years. Plague was reported in Hongkong in 1894, 1895 and 1896; also in Arabia and China in 1893, 1894, 1895 and 1896.

Bombay is a large and important port and city on the west coast of India, and in constant communication with Arabia and the Persian Gulf and the Red Sea Coast, Assyr, &c., where Plague is endemic.

The disease first appeared at Bombay and spread inland to India, west to east. The disease did not come overland across the continent of India to Bombay. It is reasonable then to assume that it was introduced by shipping. The trade between Bombay and Hongkong is small compared with the other Indian Ports, as Calcutta, Rangoon and Singapore, &c. Ships trading between Hongkong and Bombay touch at many ports before reaching Bombay, but no history of Plague is known previously at any of the ports of India and Burma, previous to the outbreak of Plague in Bombay in 1896, nor did Plague appear at any city inland between Kumaon and Bombay. It appears, therefore, more than probable that the disease came from the Persian Gulf or Arabia, being brought either by pilgrims who come and go to the extent of 20,000 per annum, merchandise or grain, rats or vermin. The disease appeared first in granaries or quarters occupied by merchants near the docks.

Once introduced into Bombay with its large population all conditions were ready for its rapid diffusion.

Plague, thoroughly established, thrives when suitable conditions are found for its sustenance, and when the people are over-crowded, live in dark, dirty, ill-ventilated, badly lighted houses ; when the houses and rooms are so dark as to require a light in the day time, when the sick and the healthy

live together, when the conditions of climate, atmosphere, temperature and moisture favour its propagation, and when the habits and customs of the people prevent measures being taken to prevent the spread of the disease; when the floors, walls, ceilings and collections of rubbish in houses form a suitable rendezvous for rats, fleas and all sorts of vermin; when the primitive method of night-soil removal and drainage facilitate the accumulation of filth and garbage, and provide a happy hunting ground and food supply for rats.

The incidence of Plague follows closely insanitary surroundings, absence of domestic and personal hygiene, over-crowded insanitary areas, want of ventilation and light and the presence of filth—in fact, the incidence of the disease is directly related to the insanitary domestic surroundings which harbour rats.

SANITATION AND PLAGUE.

Sanitation, properly applied, influences the spread of Plague. Sanitation is the result of bacteriological, clinical and epidemiological investigation into the cause of disease and embraces the whole of practical, preventive medicine, as well as the every-day work of practical sanitation. It is not for a moment suggested that the insanitary surroundings mentioned are the cause of Plague; but the insanitary condition of the people, due possibly to poverty and ignorance, is the cause of the persistence of Plague. Plague is practically confined to that class, and when it is contracted by those who pay more attention to sanitation, the disease is easy to control.

Sanitation includes not only the provision of sanitary houses and streets and proper method of drainage and water-supply, but everything which tends to improve public health and to prevent the spread of disease, including investigation into the causes of sickness and death, the provision of hospitals, medical relief, health visitors and instruction in personal hygiene and the spread of the knowledge of the cause of disease.

STATEMENT SHOWING PLAGUE MORTALITY IN THE WHOLE OF INDIA AND IN BOMBAY CITY SINCE 1896.

Year.	No. of Deaths from Plague in India.	No. of Deaths from Plague in Bombay City.
1896	2,219	1,936
1897	53,816	11,003
1898	116,285	18,185
1899	139,009	15,796
1900	92,807	13,285
1901	283,788	18,736
1902	583,937	13,820
1903	865,578	20,788
1904	1,143,993	13,538
1905	1,069,140	14,198
1906	356,721	10,823
1907	1,315,892	6,389
1908	156,480	5,361
1909	178,808	5,197
1910	512,605	3,656
1911	846,873	4,006
1912	306,488	1,717
1913	217,869	2,609
1914	296,623	2,941
1915	380,501	599
1916	205,527	1,987
1917	437,036	1,706
1918	440,752	1,143
1919	74,284	702
1920	99,368	282
1921	69,682	811
1922	77,615	632
1923	229,149	1,329
1924	361,843	409
1925	117,717	174
1926	196,249	56
1927	43,801	207
1928	121,242	257
1929	72,489	29
1930	24,840	29
1931	......	24
1932	......	37

Plague is a specific, inoculable and otherwise communicable epidemic disease common to man and many of the lower animals. It is characterised by fever, adenitis, a rapid course, a very high mortality and the presence of a specific bacterium, Bacillus pestis, in the lymphatic glands viscera and blood. In a large proportion of cases, buboes form in the groins, armpits or neck.

The characteristic microbe appears in great profusion in the buboes, in the spleen, intestines, lungs, kidneys, liver, and other viscera and also—though in smaller number—in the blood. In the Pneumonic type of the disease, it is present in the sputum in enormous numbers. It occurs also in the urine and fæces.

Yersin's experiments prove conclusively that Plague is communicable by ectozoa, especially rat fleas, principally Xenopsylla cheopis, which act as passive intermediaries and carriers of the bacillus. The Bacillus pestis multiplies in the stomach of the flea, retaining its virulence for 7 or 8 days and being passed out in the fæces; so that the flea serves not only as a carrier, but also as a multiplier of the germs.

Researches by the Plague Commission showed that Plague in man is intimately connected with Plague in rats, and that the fleas from infected rats convey the disease to man. As far back as the history of the disease goes, the rat has in some way been associated with the disease in man, and rats have been destroyed with the object of preventing it.

The following is a summary of the report of the Plague Commission's work:—

(1) That epidemics of human Plague are directly dependent on the occurrence of epidemic Plague in rats.

(2) That there is no evidence that any animals except rats play an important part in Plague epidemics.

(3) That in the great majority of cases, during an epidemic of Plague man contracts the disease from Plague-infected rats through the agency of Plague-infected rat fleas.

(4) That in large towns Plague may persist throughout the year since a few cases of acute Plague in man and rats occur during non-epidemic Plague season.

(5) Pneumonic plague is highly contagious and spreads directly from man to man probably by the droplet method.

(6) Infection is conveyed from rat to rat by the rat flea.

(7) Cases of bubonic plague in man are not in themselves infectious.

(8) Plague is conveyed from place to place usually by imported rat fleas carried in clothing, baggage etc. Transhipment or transportation of Plague carrier rats from one place to another also opens up new centres of infection.

Diagnosis of Plague in the rat.

Post-mortem appearances :—

(1) *Rigor mortis.*—Well marked and prolonged, limbs project stiffly and the carcass has a *wooden rigidity.*

(2) *Subcutaneous congestion and hæmorrhages.*—*Distinct reddish hue* on removing the skin, subcutaneous hæmorrhages seen commonly in the *submaxillary region* and *the flanks*. *Pink feet* in rats dead over one hour are quite characteristic and well marked in the fore-feet.

(3) *Buboes.*—In order of frequency, these are found in the neck, axilla, groin and pelvis. 75 % are in the neck.

In the *primary bubo,* the gland is enlarged and congested and when cut across shows hæmorrhagic points. It is recognised by the presence of enlarged hard masses in the situation of the lymphatic glands, and by the existence of infiltration and extravasation of blood in the vicinity.

In the secondary buboes, the gland is slightly enlarged and congested ; but there is an absence of infiltration and hæmorrhages.

(4) *The Liver.*—Larger than normal—*paler and pinkish* in advanced cases.

It pits on pressure and is easily lacerated. Lobules clearly demarcated and this, *combined with the yellowish* appearance of the parts affected, contrasting with the reddish colour of the congested areas, constitutes what is termed *mottling*. Small necrotic foci are scattered over its surface; these are discrete and about the size of a pin's head and show as if the liver were dusted with pepper. This granular or mottled appearance is very characteristic.

(5) *Spleen*—Larger and firmer. A necrotic patch if combined with even slight "mottling" of the liver is very suggestive of Plague.

(6) *The Pleuræ*—Pleural effusion is very characteristic. The effusion is quite clear and is often very abundant.

Remarks.—The presence of a typical bubo; after which, in the order of their importance, come the "granular" liver, subcutaneous hœmorrhages and pleural effusion.

If all these features are absent, then the rat is not Plague-infected. A rat poisoned with the "rat exterminator" may show granular liver, but in this case the absence of all other signs of Plague and the *presence of acute inflammation of the stomach and intestines,* a condition *never seen in Plague,* serve to render the diagnosis easy.

A large subcutaneous hœmorrhage without other signs of Plague is due to injury.

Rats with eczematous or hairless patches should be discarded.

NATURAL HISTORY AND HABITS OF RATS.

The habits of rats vary according to the species to which they belong. There are different kinds of rats, but for convenience they may be divided into (*a*) house rats and (*b*) field rats.

This division is not strictly accurate, because some field rats enter houses and *vice versa*.

The house-frequenting rats are of prime importance so far as Plague in man is concerned.

There are at least four common house-frequenting rats in India but they do not all play an equally important part in the spread of Plague.

Two of these four kinds can be dismissed very shortly; they both belong to the genus Nesokia, a group of rats more familiarly known as bandicoots.

Before Plague was introduced into Bombay, the large bandicoot (Nesokia bandicota) was frequently seen in houses; it is now rarely seen in houses but is found in open fields.

Occasionally, however, the lesser bandicoot (or Nesokia Bengalensis) is met with.

Among a very large number of rats found dead and caught alive in Bombay City and examined by the Plague Commission, this species constituted only 1% of the whole.

Nesokia Bengalensis—Short, stumpy, pig-like face. Broad fore-head Large ears. Rough bristly fur. Short, comparatively hairless tail.

The other two kinds of house-frequenting rats with which we are more concerned are: (1) the Rattus Norvegicus and (2) the Rattus rattus.

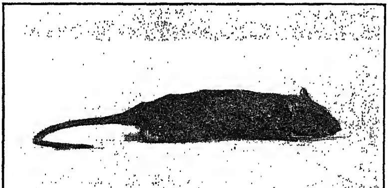
Rattus Norvegicus—This rat is comparatively rare in India. Indeed it is never found in inland villages, and has only recently established a footing in some of the larger Indian seaport towns. It is mainly a sewerrat.

It is found in Bombay City where sewers and drains exist, but it cannot be captured in the suburbs where drainage systems are unknown. It lives in burrows and drains, for the most part constructed outside the houses, but it enters houses for food.

It feeds on garbage of all kinds, it is a dirty, shy, timid rat, shunning the society of man. It first made its presence manifest in England and some other European countries coincidently with the disappearance of Plague from them.

The rat is said to have been imported from Norway; hence it has been called the Norweigian rat.

It gradually displaced in England another species, *viz.*, Rattus rattus.



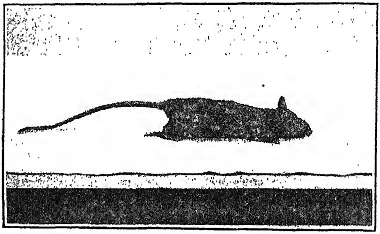
Rattus Norvegicus-

Rattus Rattus—This rat was common in England in the early Plague period. It has, therefore, sometimes been called the old English black rat. It is the common house rat of India. It is a neat, clean-living creature, very domesticated and constantly associated with man.

It lives and breeds in human dwellings, in cupboards, beneath boxes or among any sort of lumber. It finds ideal conditions for existence in Indian houses. Intimately associated with man, it readily finds shelter on ships and trains among the materials placed on board for transport.

It frequently makes for itself burrows in the earthen floors and walls of huts in Indian villages; there it breeds and multiplies with great rapidity, feeding upon the grain and other materials stored in the house.

In the island of Bombay there are probably 3 sewer rats (R. Norvegicus) to every 7 of the house-rats (R. rattus).



Rattus Rattus.

COMPARATIVE TABLE.

———	Rattus Norvegicus.	Rattus Rattus.
Size ..	Comparatively large.	Comparatively small.
Colour ..	Brown.	Dark.
Head ..	Thick and short.	Small and pointed.
Nose ..	Blunt.	Sharp.
Ears ..	Small, opaque.	Large, translucent.
Coat ..	Rough.	Smooth.
Body ..	Longer than tail.	Shorter than tail.
Habits ..	Burrowing. Lives in drains and cellars.	Lives in roofs and inside the houses.

R. rattus is a Plague-spreading rat because of its habits.

That *R. rattus* is the most important plague-spreading rat in India has been amply proved by the Plague Commission.

The Plague among *R. rattus* precedes the Plague among men by an interval of a week to a fortnight.

THE RAT PROBLEM IN INDIA.

The rat problem in India falls under the following heads :—

A. Diseases caused by rats.—
- I. Plague.
- II. Rat bite fever.
- III. Spirochætosis.
- IV. Other diseases in man and animals, *viz.*, Trichinosis, etc.

B. Material damage caused by rats.—
- I. Consumption of grain.
- II. Damage to standing crops.
- III. Damage to fabrics, structures, etc.
- IV. Accidental fires, etc.

C. Expenses incurred in rat destruction and in anti-Plague measures.—
- I. Payment of staff.
- II. Traps and poison.
- III. Anti-Plague inoculation.
- IV. Evacuation, disinfection, etc.

RATS AND PLAGUE.

The association of the rat with Plague is no new theory.

The mortality amongst rats preceding a Plague epidemic has been quoted in the history of most of the Plague epidemics for many years. Since, however, the discovery of the Plague

bacillus by Kitasato, and the presence of the bacillus in the rat during the Plague epidemics, the relation of rat Plague and human Plague has been clearly demonstrated.

The relation of the epizootic and epidemic Plague has been carefully studied in outbreaks of the disease in Hongkong (Hunter), South Africa (Blackmore and Mitchell), Sydney (Ashburton Thompson), and other places, and was early recognised in India by Simond, Hankin, Weir, and the German Commission.

Some idea of the intimacy of the correlation between human Plague and Plague in *R. rattus* can be gathered when it is stated that it has been mathematically calculated from figures supplied by the Plague Commission that the correlation co-efficient of human Plague with the *rattus* Plague of the second previous week is ·9407 with a possible error of +·0096. Statisticians generally consider a correlation co-efficient very large when it is greater than ·75. We may conclude, then, that the relationship between the incidence of Plague in man and Plague in *R. rattus* is extremely close.

The Commission, as the result of exhaustive inquiries in certain small villages, where *R. rattus* was practically the only rat caught, were able to show that the correlation in time found to exist between Plague in *R. rattus* and Plague in man held good also as regards space. Where rats died, there, a week to a fortnight later, human cases commonly occurred. They were thus able to conclude that Plague in *R. rattus* is the direct cause of human Plague in India. It is the habits of *R. rattus*, the house-rat, that make this rat so important a Plague-carrier.

The common cause of Plague in the rat and man is the Plague bacillus, a delicate organism which can only exist in the body of a living animal. The mere handling of Plague infected animals or living in contact with persons suffering from the disease, is not as a rule the means by which infection is conveyed from the sick to the healthy. Under ordinary circumstances, infection can only take place when the Plague germs are injected beneath the skin. In other words, the bacillus requires to be transferred from the blood of the sick to the healthy. This transfer of the germ from the sick to

the healthy is generally effected by the blood-sucking rat-flea, the X. cheopis.

There is however another form of Plague, the pneumonic which is conveyed by direct infection.

BREEDING.

One female rat can have 6 litters of young every year and on an average 8 in each litter and is thus capable of producing 48 rats per annum. Of these 48, nearly half are female and at the age of a little more than two months each female is capable of conception, producing in about six weeks, a litter of from 6 to 9.

FECUNDITY TABLE.

After Suschlag.

One pair of rats.

1 doe has a litter.	Dec. 29.	Feb. 15.	Apl. 1.	May. 15.	July. 1.	Aug. 15.	Litters. 6 of 8=48
1st generation: 1st litter: 4 does have litters.	Apl. 15 (a)	June 1 (a)	July 15 (a)	Sept. 1 (a)	..	4 by 4	of 8=128
2nd litter: 4 does (b) have litters.	June 1	July 15	Sept. 1	..	..	3 by 4	of 8=96
3rd litter: 4 does (c) have litters.	July 15 (c)	Sept. 1 (c)	..	..	..	2 by 4	of 8=64
4th litter: 4 does have litters.	Sept. 1 (p)	..	..	..	..	1 by 4	of 8=32
2nd generation: 1st litter: 16 does (a) have litters.	Aug. 1	Sept. 15	..	..	..	2 by 16	of 8=256
2nd litter: 16 does (a) have litters.	Sept. 15	..	..	..	..	1 by 16	of 8=128
1st litter: 16 does (b) have litters.	..	..	..	..	..	1 by 16	of 8=128
							Total..880

The young R. rattus at birth has the appearance of a tiny, hairless, red lump of flesh weighing about 5 grammes. The eyes are closed and open only after a period of two weeks. The young rat gains about a gramme per day in weight till it grows up to a weight of 100 grammes. After reaching this limit the increase in weight is not so regular as to enable one to tell the age of the rat. The young are weaned in the course of the 4th week, and reach a state of maturity on attaining a weight of 70 grammes or when a little over two months old.

DAMAGE DONE BY RATS.

Rats do great damage to property and material—by burrowing under foundations, through walls, gnawing through doors, partitions, ceilings, and house-gullies. In docks, warehouses and shops a large quantity of merchandise is annually destroyed. They have also been known to gnaw through gas and water fittings, through drains and sewers, causing thereby great inconvenience to the residents. Food, furniture, books, furs, leather and valuable textile goods, fruits, vegetable and standing crops are readily attacked and if not devoured, are destroyed by rats. In India the annual loss due to rats from all causes is estimated at 60 crores of rupees.

It is estimated by Mr. Boelter that there is a rat population in England and Wales of 40,000,000 rats, or 1 per head of the human population. Assuming that this ratio holds good in Bombay, the rat population in Bombay before rat destruction began would be 1,000,000. The natural mortality is estimated as 25 per cent. per annum and the mortality of rats accounted for by rat campaigns 25 per cent.

This does not represent the actual number destroyed, as many thousands are poisoned and their dead bodies washed out in the sewers and are never found; probably as many more are destroyed by rat campaigns, and the number is

thus kept down, because in a confined and limited area, the number could not go on increasing.

Mr. Boelter estimates in his book ("The Rat Problem") that every rat will do one farthing's worth of damage every day. This will give an idea of the damage done by rats.

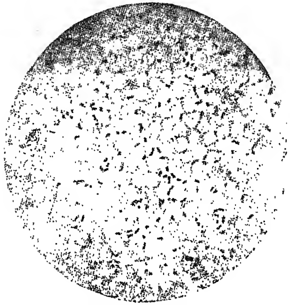
In addition to the rats caught and collected, there must be about the same number dying of other causes, or roughly 1,000,000 per annum and this represents on the above basis about £400,000, or 60 lakhs of rupees per annum saved to the commerce of the City. But it means a great deal more than that, as had these rats not been destroyed, after deducting deaths from natural causes 25 per cent. of these could have increased to 200,000,000.

It might be argued that, by killing 600,000 rats annually in Bombay, the remaining become stronger and multiply faster. It has been compared to a war where the population of a country always become greater and stronger after a war ; but in war the females are not killed, only males, while in rat-war both are killed and very often, killing a female 10 others are killed and the war is always going on and the number thus kept down. An increase of males in wild multiparous animals tends to decrease the population if there be not a corresponding number of females.

It is estimated that in the grain godowns in the City, there are rats doing a damage to the grain of at least Rs. 5,000,000 per annum.

THE MAIN FOOD OF RATS.

The R. rattus prefers as food, grain which is in common use in the locality or country. The Poona rats will prefer bajri grain, the Madras rats rice, the Sholapur rats jowar grain and so forth. In the hot weather and where an insufficient supply of water exists, the rats prefer fruit and vegetable to grain. The most popular with them are the sweet potato, melon, cucumber, coriander leaves, mango and the cocoanut.

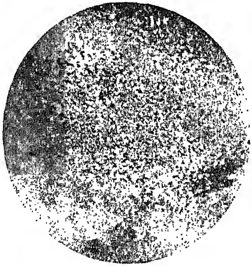


Blood of Plague-infected Rat containing Plague bacilli.

FLEAS.

There are many kinds of fleas, some being more particular than others in the selection of their host.

They are chiefly distinguished by their size and colour, the shape of their claws, and the presence of bristles on particular parts.



Stomach contents of flea showing Plague bacilli.

Besides having structural differences, fleas vary in their preference for different hosts. The rat flea generally remains on the rat, but when hungry may attack man or animal.

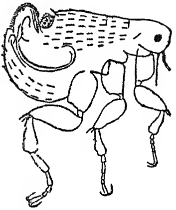
The flea seems to pass some time on the host, and the remainder in dirt, dust and sand.

The eggs, oval, smooth and white and about 12 in number, are laid in dust and dirt, and sometimes in the hair and fur of animals and hatch out in about 3 days in the summer and ten days in the winter.

The young larva is a pearly white fourteen-segmented grub (about 105 m.m. in length) with a large brown head, scanty hairs on each segment and no legs.

The larvæ live as such about 7 days and then spin cocoons and develop into chrysalids while in the dust.

These chrysalids remain in the cocoon for about 8 days, so that about 20 days altogether are occupied in the growth and development of the flea.



♂ Pulex Irritans

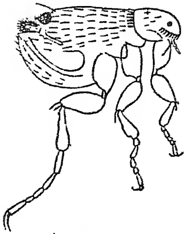
Pulex Irritans—This is the human flea. It is very select in its choice of the animal on which it feeds. It is seldom found on others than man.

It is of large size, bright coloured, eyes distinct.

Found in dark and dirty habitations. No bristles behind the head but present on posterior extremity of the abdomen. Claws, large and scythe-like.

Ctenocephalus Canis—Commonly called the dog flea, it is not very particular in the selection of its food. It will suck the blood of dog, cat, rat, man, horse, goat, guinea-pig, hedge-hog, kangaroo, rabbit, and a number of other animals, although it prefers to feed on a dog or cat and will select these animals in preference to others when they can be found.

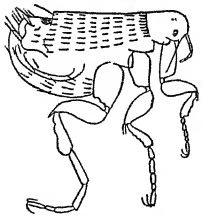
CTENOCEPHALUS CANIS.



♂ Pulex felis.

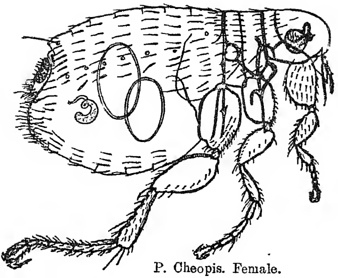
Ceratophyllus Fasciatus—The common flea found on rats in Europe is more or less particular in its choice, being generally found on rats.

This flea has combs behind the head but no bristles around the mouth. It is the commonest among the brown rat fleas.



♂ Ceratophyllus fasciatus

Xenopsylla Cheopis—The commonest Indian rat flea is of small size, bright coloured. It loves darkness and is very sensitive to light.
At first sight it resembles the human flea.



P. Cheopis. Female.

It has no bristles behind the head. It has bristles on the posterior extremity of the abdomen, and possesses elegant sickle-shaped claws. These points are perhaps better seen in the subjoined illustration.

P. Cheopis. Male.

A small flea of dark colour. Not noctural in habits and frequently found in light places.

Unlike the Ceratophyllus fasciatus, it readily feeds on a number of animals. In the absence of the rat it will bite man, especially when it has been starved for 2 or 3 days, but when rats are available, it will leave man to take to the rat.

This peculiar habit of fleas of selecting animals explains why Plague does not attack man until a few days after the death of rats. The order of events is recognised to be, first Plague among rats, then a lull, and this is followed by Plague among men. The lull can now be explained by the fact that rat fleas seldom attack man till forced by hunger to do so.

The flea, after having fed on an infected rat, escapes from the dead body of the rat and searches for fresh food ; in its passage from the place where it has left the dead rat, it comes in contact with human beings, and being hungry, will attack man. Now, it is not asserted that the bite of the flea alone is sufficient to convey the disease, although it is possible, but the flea having lived on a Plague-infected rat contains in its stomach a large number of Plague bacilli and the bacilli are deposited where the flea rests. It is thus possible for fleas to gain access into rooms, clothes and bedding of human beings, and then to bite and deject the bacilli, which gain entrance to the skin either by the pricking and irritation of the bite or by the breaking of the skin or wound. The habits of the people who sleep on the floor with scanty clothing, their uncovered feet and bodies constantly exposed to infected material, make them ready victims to this method of attack.

Rat fleas cannot travel far unless carried by a host. The rat is the common host of *X. cheopis*, but man occasionally carries these fleas on his person or clothing for long or short distances. Rat fleas cannot on their own legs travel great distances ; twenty or thirty yards would constitute for them a long journey, but carried by a host they can cover any distance. *X. cheopis*, the rat flea, is most frequently carried by rats from place to place ; but as rats usually confine themselves to comparatively small areas, and do not wander far from their holes, infection can only be spread in this way to a limited extent. At times, however, rats are carried in trains and in ships for long distances concealed among various articles of commerce, especially grain and rags. In this way rat fleas may be transported from place to place. Fleas spend a great part of their existence on the ground, and not on their host, and there too, the larva lives and feeds.

In this habit fleas differ from lice which confine themselves far more closely to a particular animal than do fleas.

Another method by which transference may take place is by the carriage of these insects by man on his person or in his clothing for long or short journeys. This means of transporting rat fleas is most likely to occur when, rats having suddenly become scarce, the rat fleas seek man to feed upon. These conditions are most often found in a Plague-infected house. People coming from such houses are liable, therefore, to harbour rat fleas on their person and some of these fleas may carry in their bodies the Plague germ. Thus it comes about that rat fleas are carried to healthy areas and, when introduced there, they leave man and seek the rats. If the rats are bitten by infected fleas, Plague may break out among these animals and later, in turn, man may become infected. In short, it may be stated that rats are usually responsible for the spread of Plague in an infected locality, but man not infrequently carries infected fleas from an infected place to a healthy area at a distance.

Plague germs can multiply in the stomach of the rat flea. This makes the flea an ideal transmitter of the Plague organism. It removes the bacilli from the blood of a sick rat, the bacilli multiply in its stomach, and then it transfers them from one healthy rat to another, till at last the affected rats die of the disease and then from hunger the fleas take to man.

On dissection of the flea, Plague germs have never been found anywhere save in the stomach and rectum.

How then does the bacillus emerge from the stomach and pass to the mandibles and thence to man?

A theory advanced by Messrs. A. W. Bacot and C. J. Martin is as under:

From experiments made with certain Plague-infected fleas which were permitted to suck vigorously at the shaven abdomen of rats, it was seen that no blood entered their stomach. The flea, like many other insects, has at the opening of its stomach a sort of valve, covered with tooth-like cells, called the proventriculus, which closes during the process of digestion. When Plague germs enter the stomach of a flea, they soon form solid jelly-like masses of bacterial culture; these drift forward into the proventriculus, choking the valve so securely that no food can enter the stomach. A flea in this state sucks and sucks, but merely distends its gullet. But

the flea's frantic efforts to assuage its thirst drive some of the Plague germs forward from the valve chamber to the gullet, and when it relaxes, some of the blood it has sucked surges from the gullet into the puncture made in the man or the rat. The blood has meantime become infected, and carries the Plague germs with it. Such is the scientific interpretation of the obscure problem—the channel of communication between the stomach of the flea in which the Plague germs multiply and the seat of puncture in either man or rat. This is probably the most usual method of infection. Certain variations in this method have been suggested but the principle remains the same, *i.e.*, infection through regurgitation of the bacilli from a distended and blocked gizzard and stomach.

Along with many other insects, the flea has the habit of passing dejecta while feeding. These may be rubbed or scratched into the bite and thus convey plague through the bites of previously infected fleas. This view has not been actually discredited.

Another possible method of infection lies in a flea interrupted in its feed off an infected animal and conveying the bacilli in its subsequent feed mechanically by contaminated proboscis or by regurgitation from the Pharynx. This view has not been accepted by the Plague Commission.

Certain points in the Bionomics of the rat flea deserve attention.

The rat flea may complete its cycle in 10 days in warm damp weather, but the usual period is 15-20 days. It can live for about 10 days apart from its host but at suitably low temperatures may live upto 2 months without food. In hot climates it can harbour the plague bacillus upto about 40 days. Although plague has been conveyed by other species of fleas and by insects other than fleas the X. Cheopis is the prime infecting factor, firstly because it is the predominant rat flea in parts of the world where plague occurs and secondly because of its proclivity for attacking other hosts including man in the absence of its natural host the rat.

PREVENTION OF PLAGUE.

Measures for the prevention of Plague are :—

1. Compulsory notification and registration of the cause of death.
2. War against rats.
3. Evacuation.
4. Disinfection.
5. Inoculation.
6. Quarantine.
7. Improvement of insanitary areas.
8. Complete system of scavengering.

9. Free medical relief.
10. Circulation of knowledge by lectures, leaflets and diagrams.
11. Rat-proof dwellings.

(1) COMPULSORY NOTIFICATION AND REGISTRATION OF THE CAUSE OF DEATH.

This measure needs no particular comment, as the necessity for it is obvious.

When ten or more fatal non-imported cases of Plague occur during a single week in any place, it should be notified as infected. The Government of India emphasize the fact that the occurrence of a single, definitely non-imported case of Plague is strong presumptive evidence of the co-existence of an epizootic amongst the rats. For this reason they consider it inexpedient that a place should be declared free from Plague until several weeks have elapsed since the last Plague-infected rat was found. This surmises that measures for the destruction of rats are in force and that rats found dead are submitted to examination—both matters of very considerable importance in the larger parts in this country.

(2) WAR AGAINST RATS.

Considering the enormous loss of lives due to Plague for which the rat, owing to its close association with man, is solely responsible, and also the vast amount of damage done by these rodents to property, material and standing crops, etc., the question as to how to prevent this loss successfully arises. The key to the problem lies in carrying out the work of rat prevention which is the first and most important of the methods, and of rat destruction which is the second and which must be persistently and without any relaxation put into force when the first, *viz.*, rat prevention is not efficiently carried out.

RAT PREVENTION.

This can be effected in various ways :—

(1) By cutting off the access of rats to their food supply especially grain, water or green vegetables.

(2) By reducing shelter to rats to the lowest possible level.

(3) By reducing easy opportunities for breeding.

(4) By separating important centres of rat infestation from areas inhabited by human beings.

(5) By educating people to consider the rat as one of their greatest enemies.

The first of these conditions can be met by enforcing the principles of rat-free and rat-proof construction. For rat free construction it is important to bear in mind that a R. rattus cannot stretch itself more than 7 inches, that its highest jump is $2\frac{1}{2}$ feet, its transverse jump 4 feet, that it burrows with its teeth and never to a greater depth than $2\frac{1}{2}$ feet, that it cannot climb up a hard, smooth and vertical surface, that its runs are close against walls and corners of rooms and that the situation of its burrows in the house or warehouse is invariably in the walls and especially at the corners at a distance of about 2 feet above the floor or a foot downwards below the ceiling.

The following rules are important for observance in rat-proofing structures :—

(*a*) The flooring should be of solid construction and fitted with stone slabs or minton tiles or other equally hard material.

(*b*) Walls should be *pucca* and impervious to rat attack; fixing of glazed tiles to walls to a height of 3 ft. is an advantage.

(*c*) The ceiling should also be of solid construction and so designed as to afford no facilities for rat runs or nests and the rooms well lighted and ventilated.

(*d*) The drains to be of sound construction and proof against rats gnawing through the joints. Disused drains should be removed and the opening at the sewer end cemented, or well protected. All holes and burrows to be well rammed in with cement or glass.

(*e*) Buildings in the docks and places where rats congregate in large numbers should have metal protectors for the foundations extending downwards to a depth of $2\frac{1}{2}$ feet into the soil and protruding onward at an angle, which angle must be filled with concrete.

(*f*) Rat-proof receptacles should be used for the storage of food and refuse.

The second condition can be met by making it impossible for rats to find shelter in drains and sewers, in farm-yards and stables, in hay-ricks and corn stacks and in compounds, by the removal of all ratty surroundings and dumps of accumulated refuse and in our residences by making the residences rat-free if not rat-proof.

The third condition can be met by disturbing the rats in various ways. House cleaning, shifting of furniture at regular intervals, etc., are some of the easy ways of achieving the object. It must be borne in mind that their breeding appears to be a very delicate process and the slightest disturbance is quite enough to upset them.

The fourth condition can be met by locating granaries, ginning factories, stables, cowsheds, slaughter houses, etc., at some distance from human habitations.

The fifth condition needs no description, but it may be added that without the co-operation of the people, no success in the campaign against rats is possible.

In many of the grain godowns and shops in Bombay, owned by Jains, rats are not allowed to be killed. On the contrary they are encouraged to live and tins of water can be seen placed in the godown for the rats to drink.

The aforesaid measures explain the logical basis of the following desiderata of grain stores :—

(*a*) Wherever possible, the wholesale storage of grain should be effected in buildings apart from those in which retail trade is carried on.

(*b*) Wholesale grain stores should not be situated in close proximity to densely-crowded areas of a city.

(*c*) Wholesale grain stores should never be utilized for purposes of human habitation.

(*d*) Bearing in mind that water is essential for the life of the rat, no water accessible to rats, or fresh vegetables should be allowed in wholesale grain stores.

(*e*) As rats are unable to circumvent a smooth horizontal projection of nine inches, such a ledge surrounding a grain store on the top of a plinth three feet high is effective in prohibiting the ingress of rats. On the sides of the building in which the docrs are situated, this ledge can conveniently be enlarged into a platform 2 feet or 2 feet 6 inches in width. Reinforced concrete is a suitable material for such ledges and platforms.

(*f*) The roof of the godown should overhang this platform and ledge to prevent the accumulation of rain water thereon.

(*g*) No steps or similar means of facilitating ingress should be allowed. In practice the incovenience caused by the absence of such steps will be found inconsiderable. For unloading sacks of grain designed for such a store, the bullock cart can be pushed close to the platform, which is also at a convenient height to facilitate the deposit thereon of sacks from a cooly's back.

(*h*) Rats will, from time to time, be introduced to such a store but they will be compelled to leave in search of water and should find their return extremely difficult.

(*i*) In villages and places where the cost of such pucca buildings is prohibitive, relatively rat-free stores can be made of almost any material, provided the roof is water-tight, by raising the floor on uprights surmounted by rat guards similar in design to those commonly employed on ships' cables. These uprights should be at least three feet high and should support the beams on which the floor rests. This floor might be made of wood. The space underneath the floor can be left open and kept free from weeds and rank growth with but little trouble. The above suggestions should be sufficient to enable "rat-free" godown, suitable for any requirements, to be designed, provided the principles on which the suggestions are made are borne in mind, suggestions which are all based on an appreciation of the habits of rats. These godowns will be so constructed and kept as to ensure a remarkably decreased rat population.

Other means of diminishing the risk of the conveyance of Plague-infection through the medium of grain and similar merchandize will suggest themselves. The diminution of the facilities, at present existing, for rats to enter goods-wagons and carts; the re-sacking of grain; the erection of platforms on which grain received loose can be bagged these and similar measures all require attention in certain cases.

Section 384 A of the Bombay Municipal Act gives powers for prohibiting godowns or places for storage in connection with wholesale trade of grain, seed, or groceries in any building intended to be used for human habitation without Municipal permission.

Legislation similar to the one introduced in England and known as the Rat and Mice (Destruction) Act, 1919, needs to be urgently introduced in India and to be such as to be easily and effectively worked by all the Municipalities, big and small, against the owners and occupiers of rat-infested premises and lands.

RAT DESTRUCTION.

The following are the methods of rat destruction :—

(1) *With the help of its natural enemies*, such as cats, terriers, ferrets, mangooses, kites, owls, stoats, weasels, etc.

(2) *By means of trapping*. Various forms of traps are on the market. There is the box trap, breakback trap, the toothed-clap trap, the well, pit, varnish and barrel or tub traps, the wire cage trap (the Wonder trap), death run and terrier blocking trap, etc.

Of the traps the most effective is the Wonder or the French Pattern Trap. For houses the Death Run Trap acts as a useful auxiliary and the Terrier Blocking serves well in places such as big yards, hotels, etc.

The Wonder Trap is very thoughtfully constructed and is made to suit the rat in its ordinary movements, so that there is no one point in it which would scare the rodent, but on the contrary fills the rat with confidence as it moves in. It is capable of capturing as many rats as can get in it.

The "Death Run" Trap is a new and efficient trap, strongly made of galvanised wire. It is intended as a run trap, and needs no baiting if set against a wall; the trap is sprung by the rats simply passing over the treadle which is counter-weighed and so cannot be sprung by vibration. There are no springs to get out of order as the doors close by their own weight.

The Terrier Blocking Rat Trap is an elongated wooden box, about 6 ft. in length, with a drowning cage attached to its narrow end. It has got two openings, one on either side which serve as entrances and another one in its roof about its middle, which is used for putting the baits in. All these are guarded by doors. In order to draw the rats towards the trap and also to induce them to enter it, a trail of baits is laid beyond both ends which is continued inside and the trap

is not sprung for a week or ten days, when first set, to allow the rats to become used to it. On the night that the rats are to be caught, the bait consisting of flour or crushed corn (which cannot be removed at once and which the rat has to nimble little by little) is placed in the centre of the interior of trap and a man keeps a watch, by keeping himself at a distance of 30–40 ft. away from the trap. A string is carried from hooks attached to the doors of the two openings and this, he pulls in order to close the trap as soon as he sees that a sufficient number of rats have got in. The trap should be sprung first time, at least three-quarters of an hour after the premises have been quiet.

The rats caught the first time may be frightened from one end of the trap when they try to pass out by the other end to which the drowning cage is attached. They jump out into the cage and get drowned in the water. The trap is now ready for effecting another catch.

This trap is especially useful for quays, slaughter-houses; knacker's yards, hotels, provision stores and such other places.

The results of rat-catching with this trap are not quite successful as much depends on the care and vigilance of the watchman employed for springing the trap.

All the three types of traps mentioned above are now used in Bombay.

BAITS FOR TRAPPING.—The best bait to be used in a trap should consist of dough made of the flour in common use in the locality. This has been found to be more successful and attractive than substances such as meat, fish, cheese, fat, spices, oils of rhodium, anisi, coriander, oil scented baits, paper baits, live rat as bait, etc.

HOW TO CONDUCT A TRAPPING CAMPAIGN.—In carrying out trapping campaigns, use traps equal in number to 5 per cent. of the population. This number will enable the

operator to set the traps in every house in his section once a week.

To be successful the work must be done systematically, under good supervision and there should be no relaxation in the operations. It is necessary that special attention should be given to trapping between successive poison-baiting campaigns and also before the commencement of and during each breeding season of the rat which extends from January to June. The traps must always be in a thorough state of repairs.

The manner in which the work should be organised should be as follows if systematic operations are intended :—

(1) Divide the City or Town into sections, and if the latter are too large in area and extent, further sub-divide them into sub-sections.

(2) Place an Overseer or Muccadum in charge of each of these Divisions or Sub-divisions.

(3) Place three rat-bigaries under the control and direction of each Overseer or Muccadum.

(4) Each bigary thus supplied to each Overseer or Muccadum must be capable of manipulating 80 rat-traps daily.

(5) Therefore place 240 traps in the charge of each Overseer or Muccadum, making him responsible for any losses or damages due to negligence, and instruct him as to the work to be done by each bigary under him.

(6) The trapping work should be carried out street by street, so that no place is omitted from the operation. In distributing the traps the following points should be observed :—

A two-storey house, a sweetmeat shop, big cattle shed, a stable, or a restaurant to be considered

as 2 houses; 4 rooms in a chawl as one house. Bearing these considerations in mind, two traps should be distributed per house every day for all the week days. Sundays should be devoted to repairs and cleaning of traps.

(7) Spots in each Division or Sub-division should be marked out and fixed for each day's collection of rats. The spots should be convenient for each day's operations.

(8) All traps should be changed and this will necessarily take place daily as the operations have to go on street by street, so that the whole of the Section or Sub-section is treated with traps in every house once a week. If any single setting gives a result of 5 or more rats, that trap may be retained on the same premises for a day or more. Care must be taken not to set a trap within 6 feet of a rat burrow.

The Muccadum or Overseer should send a slip showing the location of the trapping for the day to the Inspector in charge of the rat operations in the City daily and in addition maintain a note book possessing the following columns:—

Street.	House. No.	Name of Party.	No. of traps given.	No. of traps returned next day.	No. of rats found.	Date & Month.

Where traps are refused, a mark against the house number should be made thus "X" and where the house is found to be completely closed or locked up, the mark against the number should be "O".

The Inspector in charge should record the results as under:—

(1) No. of rats caught per 100 traps set.

(2) The percentage of traps containing rats.

(3) Average number of rats per house.

Particular note should be taken of seasonal variations in the number of rats caught per 100 traps set.

(3) *By means of poisons.*

The following poisons have been used in connection with rat destruction : the Punjab Rat Exterminator, Common Sense Rat Exterminator, Arsenic, Rough on Rats, Sodium Arsenite and Arsenate, the Bombay Municipal Laboratory rat poison, Squill, and Barium Carbonate. Of these poisons Barium Carbonate has been found to be one of the most reliable. Its advantages over other poisons are that it is non-inflammable and can be easily conveyed from place to place, that it is tasteless, ordourless, and the cheapest of all poisons so far known. In the amounts used for rat-baiting, it is not harmful to domestic animals or human beings.

Fatal doses of different kinds of Poisons.

Barium Carbonate	3	Grains.
Punjab Exterminator	3	"
Common Sense Poison	3	"
Bombay Municipal Laboratory Poison ..	3	"
Acid Arsenicum	$\frac{1}{3}$	"
Rough on Rats	$\frac{3}{4}$	"
Sodium Arsenate	$\frac{1}{3}$	"
Sodium Arsenite	$\frac{1}{3}$	"

The average fatal period.

	Hrs.		Hrs.
Barium Carbonate ..	15	Acid Arsenicum ..	30
Common Sense	20	Rough on Rats ..	32
Punjab Poison	21	Sodium Arsenite ..	53
Bombay Municipal Laboratory Poison ..	24		

HOW TO CONDUCT A BAITING CAMPAIGN WITH BARIUM CARBONATE.—Trapping operations should cease in the areas where poison baiting is to be done.

The number of baits to be prepared should be equal to at least one per head of the population in the areas to be treated.

Each bigary should have 750 baits for distribution or laying, and 150 pieces of brown paper 3″ × 3″ numbered from 1 to 150.

The residents must be given previous intimation that poison baiting of the area will commence from such a day and last to such a day, to enable them to take all necessary precautions.

At dusk and with lantern in hand the bigary should move out for carrying out his work. Each piece of paper should have 5 baits placed on it, and the laying of the pieces should be in serial order, and the places where they are kept noted. The poison should be laid in places needing the greatest attention. This the bigary can always know from his rat-trapping experiences.

When poison is to be laid in rooms, the papers (two to a room) with the baits should be handed over to the occupants with instructions as to how to place the baits and when to collect the same.

Important places such as house gullies, hedges, or dark unused rooms should never be overlooked by the bigary.

No sooner he has placed the 150 pieces of paper, each with 5 baits he must report the fact to his Overseer or the Muccadum who will check the work done by asking the bigary to point out any particular numbered paper or papers. Early the following morning the bigary will collect all the papers with baits if any, remaining on them and bring them to the headquarters. These should be checked with the list of the places where each numbered paper was laid, and the condition of the baits noted, such as, number eaten, number partially eaten or nibbled, and the number uneaten.

The success of a poison baiting campaign of an intermittent character can be said to be attained when 75 per cent.

of the baits laid are eaten. The operation will appear effective during the first three days only.

Baiting should not be continued in the same area for more than 5 days as by this time the remaining rodents would learn to avoid them altogether; but the operations may be resumed after the lapse of a month or thereabouts.

BAITING *versus* TRAPPING.

Baiting is a violent method, trapping is not so. Wiliness after baiting is absolute and prolonged, not so after trapping. Rat population is reduced markedly after intensive baiting, not so under trapping. Baiting is comparatively a cheap method; trapping is expensive. Baiting is suitable for short campaigns, trapping for prolonged campaigns. Baiting is more suitable for evacuated areas, trapping for populated areas. Baiting is extremely unpopular in populated areas owing to rats dying in inaccessible situations and the risks to children and pet animals, etc. Trapping is preferred in populated areas.

The other methods of rat destruction are:—

(4) *By means of viruses.*

There are many viruses on the market, such as "Liverpool Virus," "Ratin," etc., but the use of them has been found to be unpopular, owing to the risk of infection to man from infected rats.

(5) *By means of gas.* The one found most popular is Sulphur dioxide. This gas is easily generated and always indicates its presence by its pungent odour. The other gases are Harker's flue gas, Hydrocyanic acid gas, Phosgene gas, and Carbon monoxide gas, and are not much resorted to on account of their very dangerous nature.

(6) *By the use of Cyanogas "A" Dust.*
The use of Calcium Cyanide in the form of dust has been found to be effective and is being extensively used all over the country. It is known as Cyanogas 'A' dust.

Cyanogas is a fine dust and is guaranteed to contain not less than 40% and not more than 50% of pure Calcium Cyanide. This dust owes its value in rodent control to the fact that when exposed to the air, it is acted upon by the moisture in the atmosphere forming hydrocyanic acid gas, leaving behind a harmless residue consisting mainly of ordinary slaked lime.

There are two ways of using this dust in the destruction of rodents.

The first is to place well down into the openings of the burrows by means of a long-handled spoon an ounce or two of the dust, the holes thereafter being closed with soil alone or with a plug of grass covered with wet clay. The second is to blow dust into the burrows by means of a good dusting pump or machine.

The use of this dust is very effective in destroying rats in places suited to its use. It has also been found to be very useful for fumigation of enclosed spaces. Of course the usual precautions must be observed in operating with this material.

The advantage lies in the fact that not only are the rodents destroyed but fleas and other insects as well, and in enclosed spaces, flies, bed-bugs, green-house insects, cockroaches, ants, etc., are also killed.

(7) *By making a search for rat-holes and destroying* the blind baby rats.

(8) *By introducing the Rodier system,* which has for its object the reduction of the rat population by bringing about an inequality in the numerical sex relationship—the males being released unhurt and

females slaughtered. This process in course of time renders the male population sufficiently in excess of the females to harass the latter, and render propagation difficult with the result of smaller litters, and the destruction of the young. It also helps further in reducing the rat population as the males are killed in fighting against one another for the possession of the female.

DESTRUCTION OF RATS AS CARRIED OUT IN BOMBAY.

The Health Department of Bombay are destroying nearly 600,000 rats in Bombay every year.

Deducting 10 per cent., *i.e.*, 60,000 for rats that do no harm, *e.g.*, small rats, mice and musk rats, there will be 540,000 *Mus rattus* and *Mus decumanus*, the black and brown rats. At least half of these will be females. Thus 270,000 female rats are destroyed annually.

The procedure adopted is as follows :—

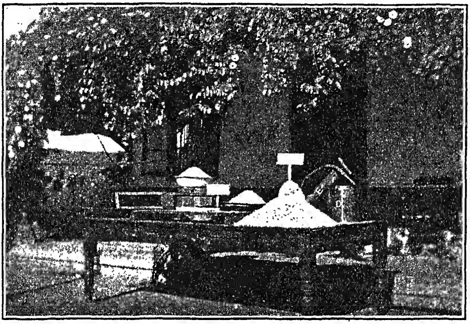
Each of the 10 Districts in Bombay has a staff specially trained in rat destruction work. The traps used are the Chitre Pattern "Wonder Traps," the "Terrier Blocking Traps" and the "Death Run Traps". The number of traps brought into use daily by each district ranges between 100 to 150.

The poison used is Barium Carbonate. Baits in the form of pills are made, each such bait containing 3 grs. of Barium Carbonate made upto 15 grs. with dough of Bajri flour.

The total number of baits prepared daily by each district is 3,500 baits.

On Sundays and holidays no baiting operations are carried out.

The Rat Staff of each district assemble at 3 p.m. each day at their respective administrative headquarters and after giving their attendance prepare themselves for carrying on work both of trapping and baiting.



POISON BAITS AND CYANOGAS APPARATUS.

A. Bajri Flour. B. Barium Carbonate. C. Prepared Baits. D. Cyanogas "A" Dust. E. Foot-pump.

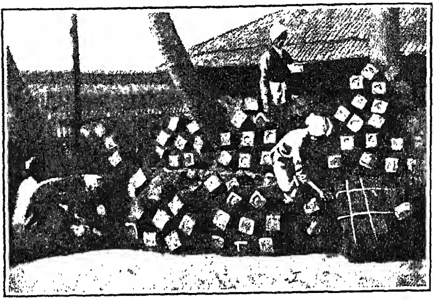
Whilst half the number keep cleaning out the traps, putting them in order and baiting them, the other half is busy preparing the poison baits.

The area to be treated is marked out in sections, and so arranged that before the week is out, the entire area of the district is completely attended to, the work starting afresh the week following.

Before it gets dusk the staff start out for the work and distribution of traps and the laying of poison baits is completed by 7 p.m., each day.

Next morning the traps are collected, so also are the uneaten baits and a search made for the dead rats.

The staff then repair to their respective headquarters or ward stables and have their catch registered. The places where rats have been taken alive or picked up dead are noted on a chart with the name of the rat-catcher and a similar entry is made in the Rat-Register.



SHOWS THE TRAPS BEING BAITED.

All results are daily sent to the Head Office and tabulated.

A map of each section is kept and the daily rat mortality and human mortality marked thereon with red and blue dots, with the date of occurrence of each case.

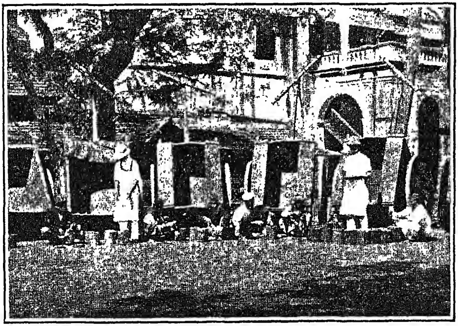
Flooding.—The method is frequently resorted to in open spaces, house-gullies and court-yards which are heavily burrowed by rats. Water under pressure is hosed into the burrows and the inmates if any are either drowned or killed by sticks with which the operators are ready, should any rodent attempt escaping.

Pumping with Cyanogas 'A' Dust.—This process is adopted in all rat-burrowed spaces, open to the air. The treatment is continued in a space taken in hand, until such time no fresh burrows are made. These two latter methods have proved very successful in open areas where trapping and baiting have failed to have any appreciable effect.

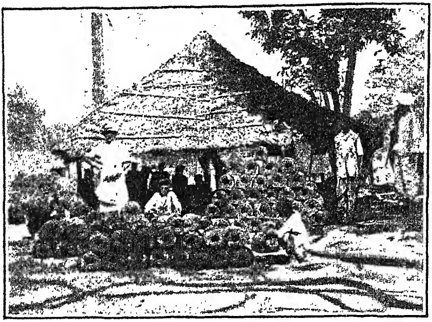
Traps and boxes containing live and dead rats are then placed in carts and sent to the Haffkine Institute at Parel for examination. On the arrival of the carts there, the box numbers and the number of rats are checked by the authorities with the statement sent from the Health Department office, as each rat-catcher has to be paid for the rats he brings.

Though the examination of the dead rats at the Haffkine Institute is a very unsavoury process, it is a very valuable index of the state of Plague. A *post-mortem* examination of rats is made, and it takes about 2 minutes to determine the presence of infection by the examination of the glands of the groin, neck, organs, &c. From 500 to 700 dead rats are thus examined daily. The live and putrid rats are not examined. The carcasses are disposed of by burning in an incinerator installed in the Institute grounds.

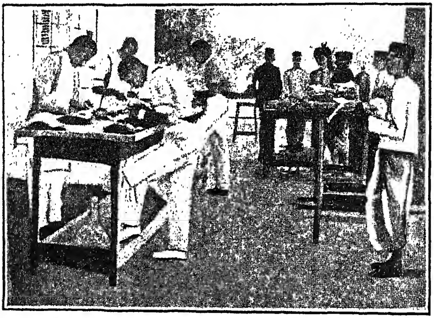
The result of the examination is sent to the office of the section in which the dead rats were found. If the rats are infected, the houses where such rats were collected from



SHOWS THE CARTS ARRIVING AT THE LABORATORY.



CHECKING THE RATS WITH THE STATEMENT SENT FROM THE HEALTH DEPARTMENT, AS EACH RAT-CATCHER HAS TO BE PAID FOR THE RATS HE BRINGS.

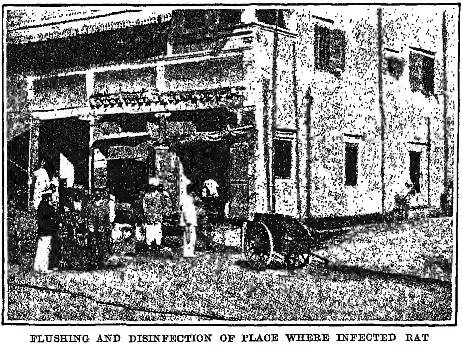


EXAMINATION OF THE DEAD RATS AT THE LABORATORY. A VERY UNSAVOURY PROCESS BUT A VERY VALUABLE INDEX OF THE STATE OF PLAGUE.

are flushed and disinfected with pesterine. The inmates are asked to move out, while the houses are being disinfected into a camp provided for them and the locality is treated with poison baits and traps.

By the examination of dead rats, the phase of the rat epidemic or epizootic is known. A rise in the epizootic is always the precursor of the epidemic in man. The rat index is thus of immense value.

Every rat-catcher must bring 7 rats per day free and he is paid at anna ½ each only for those rats over and above this original seven per day. Moreover, to prevent slackness he is not allowed to bring less than 9 rats per day on more than three occasions in a month. The original 7 free rats per day are taken as such in return for his fixed wage of Rs. 23 per mensem. Any catch over and above that number represents so much extra gain to the man. This rule applies only to the "special rat-catchers." Men not employed as such are given anna ½ per rat irrespective of numbers brought. If a rat is missed or lost on the way from the stables to the Institute,



FLUSHING AND DISINFECTION OF PLACE WHERE INFECTED RAT WAS FOUND

a distance of 5 miles, the rat-catcher loses his fee. Empty traps and tins are returned to the districts concerned.

COST OF PREPARING 3,500 BARIUM CARBONATE BAITS.

	Rs.	a.	p.
Barium Carbonate $1\frac{1}{2}$ lbs.	0	4	6
Bajri flour 4 lbs.	0	6	0
Labour for preparing baits	0	5	0
	0	15	6

There should be no relaxation in the efforts at rat destruction. The aim must be to secure at least the destruction of rats equal in number to twice and preferably thrice the human population of the area treated. Any lull in the operations will soon be followed by rapid breeding, and the town or country will soon find itself in the same position, if not worse in respect of rats, as when the operations were first started.

Dr. Howarth in his report on "Rat Repression in the City of London" says:—

"At the present time two chief conclusions seem to be justified:—

(*i*) Rats apparently multiply to the limit of the means of available subsistence. Under favourable conditions litters are large, since reproduction is carried out under a maximum of satisfactory circumstances. When food supply is less than is necessary to maintain in a satisfactory condition the rats which exist in an area, there probably results an automatic control owing to increased mortality and reduced fecundity.

(*ii*) Intermittent attempts at rat diminution almost certainly result in constant maintenance of maximum rat prevalence. The reduction which takes place as a consequence of sporadic efforts results in additional advantages being the legacy of those that remain, and a subsequent increase follows until the normal level is regained."

(3) EVACUATION.

Of all the measures that are organised for combating Plague, evacuation of the infected areas or houses as soon as an epidemic is notified, or even before that time is the only measure the people voluntarily resort to. They have great faith in this measure.

In the early days of Plague, perhaps, they were averse to leave their homes for various reasons, as they were to every measure, but when they began to understand the cause of the spread of the disease, they eagerly resorted to camps.

The principle of evacuation is a sound one and, combined with rat destruction and examination of dead rats, is of great utility in controlling the disease.

Previous to the anticipated outbreak well-built, temporary huts should be erected on suitable places not far removed from the area which will be affected. The huts should be built on a plinth in rows 20 to 30 feet apart with proper bathing places and a good supply of water, with the floor and passages tarred, and closed receptacles for the deposit of refuse provided as well as latrines and urinals.

It is possible in some cases to vacate large areas before the outbreak begins but the people generally wait until rats begin to die.

Every dead rat should be examined and the result registered; action should then be taken to vacate the building where the rats are found; the whole building baited and trapped, pesterined and lime-washed, when it can be reoccupied 10 to 14 days later.

Rat campaigns should be organised and continued all through the year.

In Bombay this procedure is followed; in some instances difficulty is experienced in moving people out, but with patience and perseverance, much can be done. The task is

no light and easy one and requires tact and perseverance—as in all such measures for the control of infectious diseases in India.

It is argued by some that disinfection and evacuation are of little use in the prevention of Plague but the concensus of opinion of those who have had acutal experience is in favour of both. It is argued that it is too late to take action after Plague rats have been found but this argument is fallacious, as has often been proved in Bombay.

A dead rat is found in a room or passage it is examined and found infected. It may be assumed that other rats are infected which may have not been picked up and not examined. It may also be assumed that each rat had fleas on it before death and that the fleas have left the rat to find another temporary host. The passing of the flea from one rat to another means that it has to travel some distance and it takes a certain amount of time in getting to the next host. In the meantime if the surroundings are properly pesterined, the fleas leaving one rat will have to pass through pesterine which they fail to do and die in the attempt.

To say it is too late to evacuate or disinfect after the death of a rat or human being is to forget what happens in every other infectious disease, where the cause is due to direct infection and not depending on the fleas. Take Small-pox, Tuberculosis, Diphtheria: a case or death occurring in a room. The room cannot be disinfected while the patient is alive, but are no disinfecting precautions to be taken to prevent the spread of the disease after the death or removal of the case?

As soon as a case is brought to the notice of the staff and the room can be vacated, one or more guinea-pigs should be put into the room in suitable cages and subsequently examined for the presence of any Plague-infected fleas. The room is locked and subsequently, when the guinea-pigs are removed, disinfected.

(4) DISINFECTION FOR PLAGUE.

In disinfecting against Plague infection, it was necessary to look for an insecticide.

The work done by the Plague Commission showed that the usual chemical disinfectants had no effect on fleas.

In 1906 Dr. J. A. Turner, the Health Officer of Bombay, seeing the results obtained in France from the use of L'huile de Schiste in killing flies and their larvæ, procured a small quantity and experimented on fleas in rat-infected houses. The result was so satisfactory that the crude fuel oil is now used as the standard method of treating all rat-infected places. The name given to the substance was "Pesterine*": and its use has become universal in India.

Disinfection with pesterine should be carried out thus. The articles required are :—(1) pesterine, (2) wooden or zinc buckets, (3) brushes, (4) brooms and (5) a watering can.

The men who do the disinfection should wear long coats and protect their feet with shoes or *chuppals*.

Begin by sprinkling pesterine on the floor of the room to be disinfected. Then remove all the furniture, etc., out of the room. Any fleas dislodged during this process will be caught in the pesterine already sprinkled on the floor.

All clothing should be collected in sacks and sent to a sterilizer for disinfection with steam.

After the room has been emptied, begin by spreading pesterine with a long brush, first over parts of the walls—up to 3 feet. Carefully go over all the nooks and cracks and ledges. Walls can be quickly done, if the brushes are used in a horizontal manner. Then sprinkle a little more pesterine on the floor, and with a broom spread it all over in an even manner. Generally, it will be found that the quantity sprinkled at first, together with that splashed while doing the walls, will be quite sufficient for the floor.

Finally, pour a little quantity into every rat-hole seen on the floor.

* Pesterine is not a **disinfectant** ; it is only an insecticide.

Disinfection is now complete and the pesterine should be allowed to stand for twenty-four hours; the room is then fit for re-occupation.

Pesterine is useful in horse and cattle stables, and for ground contaminated with urine and fæces; collections of water should be treated by pouring the oil on the surface and allowing it to remain.

Crude petroleum oils answer the same purpose, but are more expensive.

The use of Kerosene as a pulicide has been advocated by some. Various mixtures have been recommended. For method of using it see page 948.

It is now well known that Plague is conveyed from rats to people by means of fleas. It has also been found that people going from a Plague-infected place to another that is free from Plague may carry with them in their clothes, bedding or baggage the infected fleas of that place. On arrival at the end of the journey, the bedding is unrolled and the baggage unpacked, and the fleas being at liberty to hop out, do so, and immediately go to the rats of the place to feed upon their blood. These fleas at the same time infect the rats and thus the rats get Plague and die, and soon the people of the village will begin to die of Plague also, for they will catch it from the rats. Now, as this is the way Plague comes to a village, it is possible to prevent its arrival by killing all the fleas in the baggage, clothing and bedding of all new arrivals.

For the method of killing fleas by exposure of the clothes to the sun and the precautions to be observed in connection with it, see page 950.

(5) INOCULATION.

A brief reference to the Bacillus Pestis would be useful at this stage. It is a short, gram negative, non-motile, non-spore-forming organism. It grows in broth forming at first, a slightly granular or powdery deposit at the bottom and the sides of the flask holding the broth.

If ghee or oil is floated on the top of the broth, a striking mode of growth results subsequently to which the term " stalactile " has been applied. This consists of the growth of pendulous, string-like masses, which hang from the fat globules on the surface into the substance of the broth. These masses are exceedingly delicate and readily break off on the slightest shaking of the flask. The Bacillus is easily killed by heat, chemicals and direct sunlight. Cowdung floors of houses do not retain it for more than 2 days and chunam floors for not more than 1 day.

Inoculation consists in introducing a certain amount of plague vaccine in the arm of the healthy.

Liston in his pamphlet on "Plague Prevention" says :—

" This means of acquiring temporary immunity to the disease has generally been called in India "Inoculation." It has the advantage of being a measure of personal prophylaxis, which can be carried out easily and cheaply, and it matters little who else does or does not co-operate in the measure. This is a great advantage in a country like India. The inoculated acquire a high degree of protection and the mortality from the disease among them has been shown to be about one-sixth of that of the uninoculated under the same conditions.

" The following statistics are selected not because they demonstrate the best results obtained by inoculation, but because in each instance they have been very carefully examined; the records in every case having been accurately kept.

" A very virulent epidemic of Plague was raging in the village of Undhera in the Baroda State. The village was visited and a nominal roll of all the inhabitants then living in each household was made, and as nearly as possible one-half of the members of each household were inoculated. It was found that there were 950 persons then alive in the village, and of these 513 were there and then inoculated. No selection was made other than that required to make the

inoculated and uninoculated groups as similar as possible as far as age, sex and physical fitness were concerned. Plague continued in the village for 42 days after the inoculations were performed. The disease occurred in the houses occupied by 28 families. These families were composed of 71 inoculated and 64 uninoculated persons. The 71 inoculated had 8 attacks with 3 deaths, while the 64 not inoculated had 27 attacks with 26 deaths. We may infer that in this single village no less than 26 lives were saved by inoculation.

"In the Punjab a large number of people have been inoculated. Major Wilkinson, late Chief Plague Medical Officer, has given us the figures referring to villages in which more than 10 per cent. of the inhabitants were inoculated four months or less before Plague occurred in them. In these villages there were 1,86,797 inoculated as compared with 6,39,630 uninoculated persons. Among the inoculated there were 314 deaths from Plague. Among the uninoculated there were 29,723. From these figures it is easy to calculate that nearly 8,000 lives were saved in these villages by inoculation.

"Quite as good, if not better, results have been obtained in Bombay City.

"In a *chawl* near Pilot Bunder inoculation was carried out two months before Plague broke out in it. 61 persons lived in this *chawl*, and of these 24 had been inoculated. Only one of the 24 was attacked by Plague and he recovered, while of the 37 uninoculated, 19 were attacked by the disease and 12 of them died. In this single building 12 lives were saved by inoculation.

"Dr. Turner and his staff inoculated a large number of the Municipal servants living in certain Municipal chawls, with the following results:—3,317 were inoculated, while only 838 remained uninoculated. Among the large number of inoculated there were 3 deaths from Plague, while among the small number of uninoculated there were 18. Sixty lives were saved by inoculation.

"In Karachi a similar saving of life was effected. 1,245 inoculated had 4 deaths while 60 uninoculated had 5. It is easy to calculate that 100 lives were saved by inoculation.

"Among the Police in Khandesh, great saving of life was effected by inoculation. 1,508 inoculated policemen had 3 deaths from Plague, while of 230 uninoculated 4 died. 23 lives were saved.

"Railway Companies have had a like experience. The Southern Mahratta Railway Company had 1,260 of their hands inoculated in Hubli, and 760 living in the same place refused to be done. The former had 2 deaths among them while the latter had 21. Inoculation in this case saved 33 lives.

"Millowners can confirm the advantages of inoculation. Mr. Bezonji Dadabhoy, Manager of the Empress Mills at Nagpur, found that 1,116 inoculated mill-hands had 6 deaths from Plague among them, while 2,663 uninoculated mill-hands had 179 deaths from Plague. Sixty-nine lives were saved by inoculation in this case.

"So much then for the value of the protection afforded by inoculation. Although inoculation cannot eradicate Plague from a country or district, nevertheless every case which is saved from the disease is so much gain; and, moreover, it affords less opportunities for the spreading of infection by friends who would have come from other towns and villages to attend the funeral ceremonies.

"Inoculation, too, has the great advantage of instilling into those who undergo the operation that confidence which is so necessary to avert a panic. When the majority in a village are inoculated, the epidemic assumes such moderate proportions that it can be dealt with easily, nor is it difficult to adopt measures to prevent the spread of infection to adjoining areas."

The Vaccine.—Plague Vaccine is the sterilised broth culture of the Plague bacillus to which a trace of carbolic acid has been added. The dose for an adult is 4 c.c.

HOW TO STERILISE AND FILL THE SYRINGE.

The first step in the operation of inoculation is to sterilise the syringe and needle. For this purpose Kapadia's sterilising apparatus is conveniently used. The apparatus consists of a pot for heating oil or vaseline. The pot is placed on a block tin stand, which at the same time serves to protect the flame of a spirit lamp placed beneath from draughts of air. Methylated spirit is used in the lamp.

The oil for use in the cup may be olive, cocoanut, or any similar oil which has not an acid reaction, but vaseline, is very convenient, as it becomes solid when cold, and does not spill when packed for travelling.

Fit up the sterilising apparatus and light the spirit lamp. See that the thermometer is in good order and adjust it properly in the vaseline. Then take out the syringes and needles.

1. See that the needles are sharp, clean and patent. If these points are attended to, work is greatly facilitated, and the operation is much less painful. Place the needles in the vaseline.

2. See that the syringe is air-tight. This is done by placing a finger over the nozzle and at the same time pushing home the piston; if the syringe is working properly, resistance will be felt to the pressure against the piston and it will slip back when released, provided the finger has been retained firmly over the nozzle. The tightness of the plunger in the barrel can be regulated by the screw in the handle.

3. When the temperature of the vaseline has reached 90° C., fill up the syringe with the heated vaseline and empty it again into the pot. This is done to get rid of moisture in the syringe; at temperature above 100° C. any moisture is immediately converted into steam, and this causes the vaseline to

crackle and splash and may, perhaps, fracture or burst the glass barrel.

4. Now wait till the temperature has reached 160° C. Then completely fill and empty the syringe twice with the hot vaseline. A temperature higher than 160° C. injures the India-rubber plunger, and a temperature lower than 160° C. is not so efficient in effecting sterilisation.

5. With the dissecting forceps fish out a needle, which has been lying in the hot vaseline, and adjust it firmly to the nozzle of the syringe by means of the pliers, which should, previous to grasping the needle, have been dipped for a moment in the hot vaseline.

6. Now for the third time draw up and eject the hot vaseline from the syringe ; on this occasion with the needle in position. The syringe may now be carefully laid on one side, preferably supported on the lid of the syringe box and allowed to cool. The needle should not be allowed to come in contact with any article or surface.

7. A bottle of anti-Plague vaccine is then taken in hand. The number of the brew and the number of the bottle and dose to be used is noted.

Examine the neck carefully for any cracks or flaws. By handling the bottle in the same way that the index of a clinical thermometer is shaken down, leakage through such cracks may be detected. Faulty bottles should invariably be rejected, and the contents thrown out.

The bottle should then be well shaken, so as to thoroughly mix the sediment, which will be seen at the bottom of the bottle, with the fluid. *The sediment consists of the dead bacteria and is an essential part of the vaccine.*

8. To open the bottle, hold the neck in a flame, turning the bottle round all the time so as to sterilise every part of the neck. When the glass is sufficiently heated, jerk up a little of the fluid, and the neck will crack. The tip may then be knocked off by a sharp blow from a pair of sterilised forceps.

9. Now take up the syringe, draw into it a small quantity of hot vaseline, and again eject it. While the needle is still hot, draw into the syringe two or three cubic centimetres of the anti-Plague vaccine. Place the bottle on its side on the table. Then draw out the piston of the syringe to its full extent, and shake up the small quantity of the vaccine within the barrel of the syringe. Eject the contents of the syringe. This is done to get rid of some of the excess of vaseline which adheres to the interior of the syringe.

10. Again dip the needle in the hot vaseline, pass the point of the bottle through the flame, and then fill up the syringe. Get rid of excess of air by adjusting the piston. Note the graduation marks on the piston-rod, and read off four marks counting from the nozzle-end of the syringe. Screw up the discs (to be found at the handle end of the shaft of the piston) to the point noted. The syringe is now ready to deliver 4 cubic centimetres or one dose of the vaccine.

HOW TO CARRY OUT THE OPERATION OF INOCULATION.

The most convenient site for the operation is the back of the left upper arm about midway between shoulder and elbow. The skin at this spot should be well scrubbed with 5 per cent. carbolic lotion (1 in 20). The skin being then puckered up between the thumb and fingers of the left hand, the needle should be pushed through the skin in a sloping direction more or less parallel to the surface, carefully avoiding the big vessels and not penetrating the muscles, but taking care to enter the sub-cutaneous tissue. Then slowly inject the dose. Withdraw the needle of the syringe and apply for a few seconds a pad of cotton wool dipped in *1 in 20 carbolic lotion*.

The next person is operated on in the same way. The needle of the syringe is first dipped momentarily in the hot vaseline, which is kept at hand at a temperature of 160° C. The screw on the shaft of the piston is again adjusted to four spaces from the nozzle-end of the syringe, each space being

equal to one cubic centimetre. The arm of the patient is scrubbed with 1 in 20 carbolic lotion. A drop or two of the vaccine should be ejected from the syringe to get rid of any oil or vaseline within the needle. The needle is then inserted and the dose injected.

Between each operation the needle of the syringe is sterilised by dipping it into the hot vaseline.

As only sterile fluid has been introduced into the syringe, if proper precautions have been taken to sterilise the needle before each operation, the interior of the syringe need not be sterilised between the filling from each bottle. At the close of the operations the syringe should be thoroughly washed out with 1 in 20 carbolic lotion, and the needles should be covered with vaseline.

(6) QUARANTINE.

The incubation period being recognised as ten days, ten days' detention in camp is required before the person is let out. Kitasato has shown that the specific bacillus persists in the bodies of those who have recovered from Plague for at least three weeks from the cessation of the active disease and hence convalescents should be isolated for a month before they are allowed to mingle with an uninfected community.

Improvement of insanitary areas, rat-proof dwellings, careful scavengering, free medical relief etc. are additional aids in the prevention of Plague.

Very valuable suggestions as to measures to be adopted are elucidated in the Government of India Resolution 637 of 18th August 1920. They deserve serious attention. The Resolution runs as follows :—

GOVERNMENT OF INDIA,

DEPARTMENT OF EDUCATION, SIMLA.

18*th* *August* 1920.

Resolution No. 637.

The Investigation of Plague.—The epidemic of plague which commenced in India in 1896 has formed the subject

of investigation by expert authorities and of pronouncements from time to time by the Government of India. The Plague Commission of 1898-1901 presided over by the late Professor Sir T. Frazer, M.D., LL.D., F.R.S., was hampered in its investigation by the fact that the etiology of the disease had not been fully explored. But it made valuable administrative suggestions including the re-organisation of the Sanitary Department. In 1905 the Secretary of State for India in collaboration with the Royal Society and the Lister Institute created an Advisory Committee, whose investigations published in the Journal of Hygiene established the cause of plague and its dissemination and thus indicated the measures which give earnest hope of its ultimate extermination. The causes and the measures for combating the disease, were described in paragraphs 20 to 24 of the Government of India Resolution on Indian Sanitary Policy No. 888-908 dated 23rd May 1914. In 1918 there was published a Memorandum on preventive measures and in 1919 a general review of the progress of the epidemic by the Sanitary Commissioner with the Government of India. These are some among many reports which have been made on the subject in India and elsewhere.

2. *The need of a more active policy.*—The etiology and epidemiology of the disease may now be regarded as fully investigated. The application of the appropriate measures could in the circumstances of the country, only be very partial and some of these measures are by their nature opposed to the domestic habits of the people. The Government of India however are not fully satisfied that due advantage (even having regard to the difficulties of the problem) has been taken of the knowledge which is now at the disposal of the authorities and of the public at large. They believe that the extermination of bubonic plague is a matter of determined and organised efforts and that it is the clear duty of local Governments to put in train without further

delay the action which, so far as human knowledge can foresee, is bound to banish this disease from the country.

3. *Present condition favourable for such a policy.*—The present juncture is favourable for the initiation of a more extensive campaign against the disease. Owing to the character of the seasons to the gradual conferment of partial immunity from the disease upon the rat population of certain centres and possibly to a change in the virulence of the causative organism, there has recently been evidence indicating the decline in the epidemicity of plague. In 1918-19 the mortality sank to less than $\frac{1}{6}$th of the mean mortality from this disease during the past 20 years. In the year now current, though there are indications that the disease is again increasing, the mortality up to and including January, was far below the average. Plague constitutes a notable example of seasonal disease, its intensity being at the lowest ebb in July, gradually increasing till it reaches its zenith in March and rapidly declining within the next four months. It is axiomatic that in every epidemic disease with marked seasonal prevalence, the first and most obvious line of attack lies in reducing the number of foci of infection during the non-epidemic season. The opportunity thus annually offered for the extermination of bubonic plague is rendered all the more favourable now by the fact that the disease appears to be passing through a period of low epidemicity.

4. *The cause of plague.*—The advisory committee created in 1905 and its workers established beyond doubt the radical causes of bubonic plague. These are now well known and it is unnecessary to allude to them here, except only in so far as they bear on the practical problem of extermination. The disease is essentially a rat disease. The rat responsible for its maintenance is the black domestic rat or *Mus rattus*. This is the only species of rat which lives in intimate association with man. The black rat does not migrate to any distance. When the infection is present and the rat population is suffi-

ciently numerous to maintain an epidemic, an epizootic (or precedent outbreak of disease among animals), takes place. If the rat population is sparse, this epidemic either cannot arise or is of short duration. But attempts to reduce the rat population are useless unless carried out continuously and on a large scale, since prolific breeding quickly compensates the results of any, save organised destruction. The epizootic among rats is followed, after an interval of not more than 17 days by the outbreak of human plague. The infection is transmitted from rat to rat and from rat to man by the rat flea. The plague infected flea may live apart from the rat host and remain infective for a period of 23 days or in low temperatures even longer. In a hot dry climate at a temperature of 80° F. the infected flea speedily dies—the probable cause of the cessation of plague at the onset of the hot season. But in certain districts of India the climatic conditions are such that given a sufficiency of black rats to maintain the infection, the disease may persist throughout those months which in other parts of the country are non-epidemic. Moreover, in any part of India, plague may persist among rats through the non-epidemic season, without revealing its presence by unusual sickness or mortality among them.

5. *The measures for dealing with plague.*—The measures taken in India to cope with plague and its outbreak fall under the following heads: (*i*) Hospitals for the treatment of the sick; (*ii*) the evacuation of infected areas; (*iii*) anti-plague Vaccination; (*iv*) rat destruction; (*v*) the erection of rat-proof grain stores. These measures fall into two groups, according as they are intended to deal with existing outbreaks among men or to go to the root causes and by attacking the foci of disease, to stamp out the disease itself.

6. The erection of an Infectious Diseases Hospital outside the large cities has been limited in the past by various circumstances—inadequate funds, the scattered nature of the

population and the strong dislike of entering a Hospital which is evinced by large number of people.

The evacuation of infected area has in the past been the most popular of plague measures. To village folks accustomed to an outdoor life and with their fields around them, it offers little hardship and is often resorted to spontaneously and with good results. In cities it is more difficult; when enforced it has sometimes met with serious opposition and requires careful organisation and control. Voluntary evacuation of cities when uncontrolled has too often taken the form of a stampede, which carries the disease to other and uninfected areas. Anti-plague Vaccination is gaining in popularity; but the number of persons annually inoculated is small in comparison with those exposed to infection and the immunity conferred probably does not continue from one plague season to another.

7. *Need for extension and organisation of such measures (as enumerated above).*—These measures then, useful as they are, have not been carried out under perfect conditions, nor with that degree of organisation and that wide extension of application which would safeguard the people at large from the effects of an already existing epidemic. Nevertheless they have proved of benefit and if more fully organised are capable of still more satisfactory results. Until effective steps have been taken to eradicate the disease at its bases, it is necessary to persevere in them. The institution of infectious diseases hospitals, organised preparation of camps for evacuation of infected quarters, the multiplication of rural dispensaries and a great increase in the rural areas of the number of medical practitioners capable of performing inoculation—these are measures which it is incumbent on provincial and local authorities to continue so long as India is exposed to the epidemic and until the disease can be finally extirpated. Above all, propaganda work is essential

in order that knowledge may be disseminated regarding the nature of disease and the value of proper treatment of evacuation of infected places and of inoculation.

8. *Measures for dealing with the black rat.*—The measures beneficial as they are and more beneficial as they may become if more fully organised and extended, form only palliatives and, even if carried to their highest perfection, are incapable of striking at the root of the trouble. They constitute a useful line of defence against an attack already in progress. But reliance upon merely defensive tactices is futile in the contest against a disease, whose causes and the sources of whose supply will remain unimpaired by the prosecution of these measures. The treatment hitherto adopted is the minimizing of human plague. The true enemies are the rat and the rat flea. The black rat is the primal cause and the host which carries the seeds of infection. It is only through offensive measures against the rat that a successful issue can be expected.

9. *Value of improved housing and sanitation.*—Such an attack does not necessarily or even most desirably proceed solely by way of rat destruction. The separation of man from rat is equally effective and in some centres may prove more suitable. This is evidenced by the history of plague in Europe. As late as the 17th century the houses of European cities were habitually overcrowded, small and dark. The towns were largely inhabited by farmer population. Cattle were kept in the town dwellings. Grain was stored in the houses. The black rat who is a dainty feeder, consequently found ample food in and about human dwellings and took up his abode in close domestic association with man. The result was the creation of foci of infection and violent epidemics of plague. Improvements in housing conditions, measures of sanitation and the storage of grain in appointed places, rendered the haunts of men a less comfortable house for the black rat. The close domestic association of this animal with man was thus broken and as an inevitable result, bubonic

plague disappeared from Europe. Upto the middle of the eighteenth century the predominating rat species in Europe was the black rat (*Mus rattus*); now the commonest is the brown rat (*Mus norvegicus*) which is never found in such close association with man. With the departure of the black rat from the houses of men and the consequent diminution of the species, the epidemic naturally died.

Thus good housing and sanitation are the surest means of extirpating plague. In recent years town improvement schemes have been initiated in India and experts have drawn up plans and specifications of houses which can be built at reasonable cost and will afford no comfortable habitation for the rat. Such measures however involve long periods of time for their completion and are dependent upon the provision of funds and the extent to which the population at large are prepared to accept them.

10. *Other measures.*—Pending such general improvements, the next best solution of the problem consists in the protection of grain from the rat by means of better storage. This is a measure of the highest importance and, the Government of India believe, is not impracticable.

Paragraph 15 of this Resolution deals with it in greater detail. But the provision of improved grain stores also will be a lengthy process; and meantime the destruction of the rat presents a means of protection deserving of consideration.

11. *Rat destruction.*—Experiments have already been made with rat destruction in the Punjab and at Satara. The Indian Research Fund Association has turned its attention to the problem and Major F. G. Kunhardt and Dr. G. D. Chitre were employed to make a series of experiments. The practical lessons gathered from their labours have been published in useful form.

The difficulties attending rat destruction are as follows :—

(*i*) In order to be effective, the operations must be organised and on a large scale. Ill-organised or inadequate attempts are worse than useless.

(*ii*) The best means of destruction have yet to be devised.

(*iii*) Unless the process is continued from year to year it is useless.

(*iv*) Amongst some communities, the destruction of rats is regarded with aversion.

These difficulties are serious and the cost entailed in organised measures is considerable. But rat destruction as shown in the succeeding paragraph cannot be overlooked since it forms a valuable factor in the campaign against disease and in the efforts after national well-being. So fully is this realised in the United Kingdom that recent legislation has made it incumbent upon the owners and occupiers of land in the British Isles at risk of substantial penalties, to take all necessary and reasonably practicable steps for the destruction of rats and mice and against infestation of the land by these animals. Full time experienced executive officers have been appointed to this end by many local bodies and by some industrial concerns.

12. *Economic and sanitary value of rat destruction.*— On economic grounds or considerations alone, the universal adoption of measures for rat destruction is desirable. It is hazardous to make any computation of the damage caused by rats in India. But it is probably that in British India alone, the number of black rats (exclusive of other species) is about 375 millions; the quantity of grain devoured by them during the course of a year would amount to about one million tons. On this computation and placing the cost of a ton of grain on the average at Rs. 160 the annual loss caused by the black rat in British India would be 16 crores of rupees or at a 2 shilling rate of exchange, 16 million sterling. That this is a conservative figure is shown by the estimate, based on far more reliable data where a rat population of only 40 millions is computed to cause material damage of 15 millions sterling (pre-war) annually. The Indian calculation deals only with

the loss represented by the food of the black rat, not with loss from the wastage and other forms of destruction (to houses, etc.) for which it is responsible, nor with the additional damage perpetrated by the field rat. But the economic aspect of rat destruction is entirely overshadowed in India by the Health Aspect. The diseases especially plague which the rat brings in its train, occasion a loss of efficiency and a wastage of adult life which not only seriously hampers development but causes an immeasurable amount of pain and preventable affliction. During the last 20 years plague has been responsible for an average of half a million deaths each year. The black rat is the originator and source of this disease. Even in countries not liable to plague epidemics, it has been recognised as the most expensive of domestic animals. Where plague exists such an expression falls short of an adequate description of the loss which it inflicts. Its extermination will assuredly be followed by a complete cessation of bubonic plague; a substantial diminution in its numbers by a lessening in the extent and virulence of epidemics.

13. *Principles which should govern Rat Destruction.*—Government of India therefore maintain that, save in localities where it is strongly opposed by popular sentiment, rat destruction forms, under present conditions, a necessary factor towards elimination of plague. It is not necessary to institute (at least for health purposes) a universal campaign against the black rat. Apart from the portions of India where the rat or flea population is insufficiently large to create or maintain an epizootic, there are large areas where the extermination of the rat, though advantageous from the economic point of view, would be needless and ineffective for the stamping out of plague. Rat destruction can be usefully carried out on the following principles :—

(*i*) Continuous measures are necessary in the grain centres to which grain is imported from a distance.

(*ii*) In years where there is a likelihood of the importation of infection, measures are necessary in subsidiary grain centres and market towns.

(*iii*) In villages and towns (especially those which are market centres) where infection persists during the non-epidemic season, measures are necessary during that season and also during the subsequent plague season.

In all the cases the measures taken must be well organised in order to be effective. Special and experienced staff is necessary. In the larger grain centres where continuous destruction is desirable, the number of rats annually destroyed should be sufficient to keep down the rat population below the danger zone or level, *i.e.*, below the point at which an epizootic is probable. Experience appears to show that if the number of rats annually destroyed equals or exceeds the human population of the locality, the likelihood of plague becoming established is greatly diminished.

14. *Isolation of the Rat.*—The second method which it is desirable under present conditions to prosecute is the isolation of the black rat from men, *i.e.*, its elimination from human dwellings. In his admirable report on plague Major Norman White, lately Sanitary Commissioner with the Government of India, specified two main lines of action—the improvement of markets and of grain stores of towns and the control of movements of grain and like merchandise from and through plague-infected centres.

15. *Improvement of Grain Stores.*—The improvement of grain stores is manifestly free from some of the difficulties which rat destruction involves. Religious scruples are not touched, though some opposition is inevitable to any action which disturbs domestic habits; the better storage of grain is so obviously indicated both from the sanitary and economic points of view that hostility would soon be converted into appreciation. If the natural food of the rat is not to be found

in the homes of men, it will desert those homes. Similarly if grain stores are maintained in a city, but are so organised as to be unapproachable by or useless to the rat, its number will diminish and the probability of an epizootic will be decreased.

The methods which can be adopted are therefore twofold:

(*i*) Markets and grain stores can be removed from inhabited areas. The result will be that the rat can no longer live in contiguity with man, and if the stores are so constructed as to be rat-free, the number of rats will be so much diminished as to make an epizootic among them unlikely.

(*ii*) Rat-proof or rat-free stores may be constructed in a city. The rat-proof godown is one which a rat is unable to enter. It presents difficulties in construction and involves considerable expense. The rat-free godown is one which the rat can enter, but where it cannot remain. It is easily built. Major N. White has made a design which can be carried out at a reasonable cost (10′×10′ is estimated to cost Rs. 640). Apart from some details of construction the essentials are the exclusion from its proximity of any rooms occupied by man. In addition to Major White's plan a standard plan has been published by the Madras Sanitary Board. Godowns on the former plans are being constructed at Lucknow and at Nasik. Railway Companies have been requested to take steps against rat infestation of goods-sheds and the access of rats to wagons.

The task of improving grain storage at the large distributing centres alone is one of magnitude and of time. But no measure is of greater importance for the extirpation of bubonic plague and other diseases quite apart from economic reasons.

16. *Control of Grain Movement.*—The control of grain movement would, if possible or feasible, be of great value. For the black rat does not migrate from place to place, and

plague can be disseminated over the country only by the conveyance of an infected rat or flea in merchandise or clothing. The rat population is densest at grain centres; and it is just to such centres that the infection is most likely to be carried. But economic considerations weigh heavily against the adoption of such control. A possible alternative is the erection at the larger distributing centres of plant for the disinfection of grain by Hydrocyanic Acid.

17. *Summary of Measures.*—The cause of plague and the methods which may be adopted for its elimination have now been surveyed. Investigations have shown that an epidemic of plague is invariably preceded by an epizootic among black rats. The black rat is not migratory, save when living in proximity to man; he is therefore harmless as an infective agent. A reduced rat population, even if it remains in proximity to man, is incapable of maintaining a serious epizootic. While therefore the palliatives hitherto adopted *viz.*—hospital treatment, evacuation of stricken areas and anti-plague vaccination—must be sedulously maintained and the facilities for them increased, it has to be recognised that these are mere palliatives, that the initial responsibility for the outbreak and spread of bubonic plague rests on the black rat, and that the destruction or segregation of this animal is the obvious and only method which will exterminate plague. Since any measures which involve construction of buildings and considerable initial outlay must necessarily take time it is necessary in the meantime to depend upon rat-destruction carried out continuously in large grain distributing centres and as required in villages and towns. But the erection of rat-proof or rat-free grain stores resulting in the diminution of the rat population is a method just as effective and free from the objections which might possibly be held to attach to rat destruction. The Government of India trust that the Local Governments while neglecting no other method which may in the meantime assist in decreasing or eliminating this disease will turn their special attention

to the prosecution of this reform—a reform which, if carried out, would exercise a profoundly beneficial effect upon the health and economic well-being of the people at large. Finally the ultimate goal of better housing and improved sanitary conditions will, the Government of India are assured, be kept steadily in mind.

18. *Conclusion.*—The Government of India feel that the present is a favourable time for taking more active steps than hitherto for the extirpation of a scourge which has infested India for nearly a quarter of a century and has cost her millions of valuable lives. They look for their medical experts, who have already added so greatly to the sum of knowledge and to the diminution of human suffering and to the Indian Research Fund Association under whose auspices valuable investigations have already been made, to carry out such further detailed researches as the Local Authorities in Administrative Control may find necessary for the practical application of the scientific knowledge already obtained. But it is for the Local Governments to initiate a progressive policy and attack the disease at its source rather than wait for renewals of its onset. Public health will in future be a transferred subject and the Government of India consider that no more beneficial channels of activity can be found by future Ministers of Health than the extirpation of epidemic diseases which at present threaten the Indian population.

CHOLERA.

Cholera is an acute infectious disease characterised by profuse purging and vomiting of a colourless serous material, muscular cramps, suppression of urine and collapse, and a high mortality, a special bacterium—Koch's Comma vibrio—being present in the intestines and discharges from the bowels. Cholera is mainly a water-borne disease, due to water having become infected with the Cholera organism from some person suffering from the disease. But other factors including the personal and direct infection cannot be ignored.

CHOLERA IN BOMBAY, CALCUTTA AND BRITISH INDIA COMPARED.

In the following statement is compared the mortality from Cholera during 1901-1932 in the cities of Bombay and Calcutta and in British India; the death-rates per 1,000 of population are inserted :—

Year.	Bombay.		Calcutta.		British India.	
	No. of deaths from Cholera.	Death-rate per 1,000 of population.	No. of deaths from Cholera.	Death-rate per 1,000 of population.	No. of deaths from Cholera.	Death rate per 1,000 of population.
1901 ..	198	·25	1,720	2·02	271,210	1·21
1902 ..	75	·09	2,716	3·20	224,136	0·99
1903 ..	17	·02	1,990	2·34	312,854	1·38
1904 ..	219	·28	2,056	2·42	192,835	0·85
1905 ..	26	·03	2,323	2·74	441,786	1·96
1906 ..	1,241	1·26	2,504	2·95	690,519	3·05
1907 ..	439	·44	3,803	4·48	408,102	1·81
1908 ..	95	·09	3,694	4·35	591,725	2·61
1909 ..	727	·74	2,022	2·38	239,429	1·06
1910 ..	107	·10	1,901	2·4	430,451	1·90
1911 ..	123	·12	1,860	2·1	154,005	1·90
1912 ..	1,790	1·82	2,244	2·5	407,769	1·71
1913 ..	125	·12	1,764	1·9	294,815	1·24
1914 ..	221	·22	1,983	2·2	280,730	1·18
1915 ..	61	·01	1,612	1·8	..	..
1916 ..	141	·14	1,335	1·5	288,047	1·21
1917 ..	16	·06	866	·96	267,002	1·12
1918 ..	1,682	1·69	1,526	1·7	560,802	2·35
1919 ..	8,455	8·63	3,688	4·1	..	..
1920 ..	119	0·1	2,302	2·4	130,140	·55
1921 ..	70	0·1	1,997	1·8	450,608	1·27
1922 ..	15	0·0	1,269	1·4	121,679	·50
1923 ..	189	0·1	914	1·0	73,002	·30
1924 ..	34	0·0	1,197	1·4	293,707	1·22
1925 ..	82	0·1	996	·92	115,645	·48
1926 ..	5	0·0	1,711	1·6	138,151	·57
1927 ..	28	0·1	2,171	2·0	304,710	1·26
1928 ..	34	0·0	2,584	2·4	351,305	1·45
1929 ..	8	0·0	2,571	2·4	295,434	1·22
1930 ..	40	0·0	1,755	1·6	337,322	1·40
1931 ..	80	0·1	..	..	..	..
1932 ..	7	0·0	..	..	..	..
Total. (1901-32)	16,453	..	61,074	..	8,667,920	..
Annual Average	514	..	2,036	..	309,568	..

Etiology of Cholera.

Cholera is now accepted as being due to a living organism —Koch's Cholera bacillus which, growing in the intestines of the patient, causes death partly by the effect of the toxins produced by it and partly by the profuse purging which it sets up. Further etiology of the disease resolves itself into two factors: first, the means by which the microbe gains access to the body; second, the conditions which render the body susceptible to the microbe. Of the first of these, we know much, of the second, little.

Mode of Access.—It is certain that Cholera is not contagious in the ordinary sense of the word as Small-pox, Scarlet Fever or Measles. Nurses and those who attend to the sick are often affected in larger porportion than others; but this is readily explained by the fact that, unless constant care is exercised in regard to cleanliness of hands and utensils, they are much more exposed than are others to the known and recognised mode of infection, which is by the mouth. All evidence goes to show that the infection of Cholera to take effect must be swallowed.

As in all zymotic diseases, the *materies morbi* greatly increases within the body of the patient during the progress of the malady. During the disease a minute amount of infectious material grows into an amount capable of giving the infection to thousands and, in the case of Cholera, this infectious material finds its exit from the patient's body in the discharges caused by the disease.

The study of the etiology of Cholera, then, is to a large extent a study of the steps by which matter, that has left one patient, so gains access to some article of food or drink as to be swallowed by some one else.

It is conceivable that, in the presence of a great abundance of the infection, it might be inhaled in the form of dust; of this, however, there is no evidence.

It is with food and drink that it commonly gains access to the human body. Well authenticated instances are related in which flies have appeared to carry the infection from Cholera dejecta to milk and various articles of diet; and Haffkine detected Cholera bacilli in specimens of sterilised milk, exposed in new vessels, to which flies were permitted free access during an epidemic of Cholera. The use of Cholera-infected water for washing cooking utensils and articles used in the preparation of food is another mode of local distribution. In the cases of nurses and those who attend to the sick, or have charge of the dead, the Cholera poison may as a result of want of strict cleanliness, be transferred to the mouth by the fingers, either directly or by means of food or drink.

It has been universally accepted that the great, the persistent and the almost universal mode by which the Cholera germ gains access to the body is through the drinking water. This is now so well recognised that it is unnecessary to go again over the evidence by which this has been proved to demonstration. It is unnecessary here to refer to the classical examples of this mode of Cholera distribution.

This, however, is not the only mode by which the disease is spread in the larger cities of India. When a wholesome supply of drinking water is provided, the ignorance and carelessness of the people in preventing the pollution of the domestic supply, the storing of water in dirty vessels and the constant use of well and tank water to which infection may be conveyed must be an important factor.

The habits of the people, the customs with regard to the dead, the modes of preparing, storing and consumption of food, the insanitary condition of their houses, the proximity of privies and bathing places to living rooms, and the opportunity given to food and milk to become infected by personal contact and flies during an epidemic must provide an enormous source of danger.

There is a good deal of evidence to show that water does not act as a mere diluent and distributor of the Cholera poison, but that, under certain conditions, the Cholera bacilli grow and for a short time increase in virulence during their sojourn in this medium. The persistence of Cholera in a district is indicative of more than a single pollution of the water-supply and generally points to a persistence of some insanitary conditions which favour repeated infection.

It is not always the case, however, that the infection is conveyed directly from man to man by means of water. Where we find sudden outbursts of the disease affecting large numbers of people drawing their water-supply from a common source, some direct and wholesale fouling of the supply is generally the cause of the mischief. But much more commonly, especially near its endemic home in India, Cholera does not occur in great outbursts; small local epidemics arise, die down and then recur. The Cholera bacillus existing, as we must presume, in the foul soil is now and again washed into the wells, and so sets up disease in those that draw their water from them. The key, then, to this side of the etiology of Cholera is to be found in the habits of the people and the degree of care or want of care they exercise in the protection of their water supply.

Individual susceptibility.—The etiology of Cholera is not, however, completely explained by the statement that it depends on the ingestion of Cholera-infected water; another condition is also necessary, namely, the susceptibility of the individual. Considerable differences exist in the habits of the various members of every community: thus, it often happens that even where the habits of the majority are foul, a few are protected from receiving the infection by the greater cleanliness and propriety of their lives. Yet many fail to sicken, although they are known to have swallowed the very infective matter which at the same time is producing Cholera in others. We have proof of this in every widespread water epidemic; the number of those who swallow the poison must

in these cases vastly exceed the number of those who are attacked by the disease. Macnamara gives an instance in which a vessel of drinking water was accidentally polluted with fresh Cholera excreta, and after being exposed to the sun all day, the water was partaken of by nineteen persons; of these, five only subsequently suffered from Cholera. It seems clear that the inhabitants of the areas in which Cholera is frequently present, notwithstanding habits which expose them continually to chances of infection, are much less frequently attacked than new arrivals in the districts, much less, for instance, than Europeans although, when attacked, they succumb more readily.

Dissemination by human intercourse.—There can no longer be any doubt that Cholera is disseminated by human intercourse. The march of Cholera coincides with the march of man, and it is carried from place to place either by infected man or by Cholera-tainted clothing. The part played by pilgrimages, *e.g.*, the pilgrimage to Mecca, is well known, and severe outbreaks and wide dispersion have often followed on such movements of large bodies of men. There seems to be some limit to the distance to which it would be possible to transmit the infection in a bundle of imperfectly dried rags soiled by Cholera excreta; man can carry the disease so far as he is able to travel between receiving the infection and being laid low. What we find, then, on comparing the march of the earlier epidemics of Cholera with those that have occurred in more recent years, is that whereas when travel was slow the disease swept steadily forwards, occupying the land as it advanced, in later times it has bounded forward with long strides, occupying outposts far ahead of infected areas, by means of railway and steamboat communications and then, from these outlying foci of infection, has spread in both directions coalescing perhaps at a much later date with the main body of the epidemic which has slowly advanced across the country from earlier centres.

Certain as it is, however, that man is the porter by whom Cholera is introduced to any place, it must not be forgotten that its development in that place depends on insanitary circumstances, the chief condition necessary being the liability of the drinking water to be contaminated by infected excreta. There are probably other but more obscure conditions still unknown to us.

Even amidst the conditions of soil and climate most favourable or most inimical to Cholera, its prevalence largely depends upon the habits of the people : however largely present its contagium may be, it is harmless unless swallowed. Thus, among all the influences making for Cholera, the most important are those habits of carelessness as to the cleanliness of food and drink, which make it easy for either the one or the other to be tainted with fæcal material.

To summarise, an outbreak of cholera depends on :—

(*a*) the strength and quantity of the dose of the virus received,

(*b*) the condition of the infected material which gains access to the Intestines,

(*c*) the physical condition of the patient and his power of resistance.

(*d*) certain climatic conditions,

(*e*) sanitary surroundings of the people ; water, food, drainage and refuse disposal and the habits of the people.

PERSONAL ELEMENT IN THE SPREAD OF CHOLERA.

It is impossible to analyse the evidence collected during the outbreak in Bombay without coming to the conclusion that the personal element has a great deal to do with the spread of Cholera in India. Without labouring too much on the habits and customs of the people, there is no doubt that the spread of Cholera is greatly due to direct infection

from person to person by means of the discharges, contaminated hands, food, vessels, milk and water, and flies.

The filthy privy baskets, overflowing into open drains and thus soaking into sub-soil or storm-water drains, the position of the water and sewer pipes and the common washing places are a constant danger at any time, but in the presence of Cholera must contribute to a large extent to the circumstances favouring the spread of the disease.

For example, on visiting a person suffering from the disease, he or she will be surrounded with relatives and friends handling the patient. Many will be found occupying the same room, sleeping on the floor; they all use the same privy and washing place, use the same vessels; the water is stored in wooden, iron, earthenware or other vessels, in the living room, cook-room or *nahani*, for days together. The friends and relatives will wash the dead body and take it to the burial ground or burning *ghat* and afterwards wash in the nearest tank or bathing place, without any precautions as regards disinfection.

BACTERIOLOGY OF CHOLERA.

The bacteriology of Cholera has provided the subject for an enormous amount of work. Koch, who discovered the Comma bacillus, visited India in 1883 and was followed by Klein and Gibbes in 1885 and later by Haffkine.

It is unnecessary to repeat the investigations of eminent observers and the enormous amount of work done in the bacteriology of Cholera which have brought us to our present knowledge. It is accepted that the vibrio called the Comma vibrio of Koch is associated with Cholera; that the organism exists in the stools of Cholera patients, that it can be isolated and can exist in water; that the stools of Cholera patients, either directly from the body or from the clothes and discharges, can infect water, food and milk and thereby convey the disease.

When the vibrio leaves the infected person it loses its virulence in direct ratio to the time and conditions to which it is subjected.

During an epidemic of cholera in a locality and in endemic areas, certain organisms can be isolated from the water supply which though, resembling the cholera vibrio in morphological and cultural characters differ from it as they are not agglutinated by the anti-cholera serum. These have been called "cholera-like vibrios" to distinguish them from the true cholera vibrio. Latest researches show that agglutination by the anti-serum is not an essential characteristic of even the true cholera vibrio which shows wide variations in this respect and on this and other evidence, is based the view that "cholera-like vibrios" may be the mutation forms of true cholera vibrio, so transformed by the environment through which they have passed or in which they are sojourning. Given suitable circumstances "cholera-like vibrios" may be potentially as dangerous as the true cholera vibrio. (Tomb & Maitra, Brahmachari, *Indian Medical Gazette,* 1927.)

The following routine method has been used in the examination of the samples for cholera in the Bombay Municipal Laboratory:—

For samples of water—

I.—90 c.c. of the water are transferred to a narrow mouthed sterile flask containing 10 c.c of concentrated peptone solution. This is placed in the incubator at 37° C. for 24 hours.

II.—Smears are then made and examined microscopically after staining with 1-10 Carbolfuchsin. If the smears show any Cholera-like organisms, then one of the following methods is followed in isolating the pure culture of Cholera vibrio.

III.—*Method A.*—

(*a*) One loopful is removed from flask (1) containing 24 hours culture on peptone and put in a broth tube This is labelled (2).

(*b*) A sub-culture is immediately made on slant agar (2*a*).

(*c*) Further dilution is now made by taking a loopful from (2) and putting it in a broth tube labelled (3).

(d) An immediate sub-culture is made from (3) into slant agar (3a). The tubes are then incubated at 37° C. for 24 hours.

(e) At the end of 24 hours, several suspicious-looking colonies are selected from (2a) and (3a) and examined in the usual way microscopically.

(f) Such isolated colonies are again sub-cultured on agar for 24 hours, after which they are subjected to other tests for Cholera vibrio (*q. v.*).

Method B. for isolation of Cholera vibrio.—

In this method 48 hours' old peptone cultures are plated on petri dishes and incubated at 37° C. for 24 hours. Several colonies are picked up from these and examined in the usual way.

IV.—*The pure sub-cultures obtained by method A are then examined as follows* :—

(1) Morphology.

(2) Motility.

(3) Cholera red reaction:—

(a) Nitroso-indol reaction with sulphuric acid (this is tried in 24 and 48 hours).

(b) Ehrlich's Rosindol reaction with Para-di-methyl—amido-benzaldehyde. This is also tried in 24 and 48 hours.

V.—*Staining for flagella*:—

Stephen's stain is used on a fresh sub-culture (under 24 hours)

VI.—*Agglutination test*:—

This is tried with serum usually obtained from the Haffkine Institute, Parel.

Samples of fæces:—

These are either passed through peptone water and isolated on slant agar or diluted through broth and immediately inoculated on slant agar. The rest of the method is the same as in the case of water.

The method of examining samples other than those of waters or of fæces does not differ materially from method No. 1 (*q. v.*), excepting that a smaller amount of peptone water is used up.

CHOLERA CARRIERS.

The following is an extract from a report prepared by Dr. Crendiropoulo, Director of the Bacteriological Laboratory of Chatby, Alexandria, published by the Conseil Sanitaire Maritime and Quarantenaire of Egypt, upon an examination of the stools of travellers coming from countries infected with Cholera. The investigation was started owing to the

following incident:—On August 16th, 1911, a Belgian steamer arrived at Alexandria from Smyrna, where Cholera was present. On the fifth day of the period of quarantine, a little girl, five years of age, died with symptoms suggestive of Cholera. At the necrospy the characteristic lesions of this disease were not found, but bacteriological examination revealed the presence of abundant vibrios, and cultures made from them were powerfully agglutinated by Cholera serum. Examination of the stools of all the other persons on board the steamer showed that one woman, a servant in the family to which the dead child belonged, was a carrier of an agglutinating vibrio. Other incidents of similar nature occurring within a few days showed the danger these carriers represented for Egypt, and the Conseil Quarantenaire, on the proposition of Dr. Armand Ruffer, authorized the quarantine authorities to carry out bacteriological examinations as part of their visit in all cases where they considered it necessary. In consequence, between the dates of August 17th, 1911, and January 31st, 1912, the passengers and crews of 297 vessels were submitted to an examination of the stools as part of the routine examination for quarantine. The total number of stools examined was 34,461 and of these 14,553 were obtained from the crews and 19,908 from passengers, mostly from those of the poor class, although in some instances every person on the boat was examined. Vibrios were found in 63 cases, and of these 23 possessed agglutinating properties with Cholera serum, while 40 did not. Of the 23 agglutinating vibrios, only 2 came from members of the crews, while of the 40 non-agglutinating, 12 were found in members of the crews. The percentage of agglutinating vibrios was, therefore, about 0·07, but it was found that in the 44 days from August 17th to September 30th, during which the epidemic was at its height, there were ten times more carriers than during the remainder of the period. In general, Dr. Crendiropoulo finds that agglutinating vibrios are only found in travellers from infected countries and only when an epidemic is at

its height. During the decline of an epidemic, carriers become extremely rare. It is interesting to note that the greater number of carriers were found in passengers and that the crews were but rarely affected. All the carriers were kept in quarantine until the disappearance of their vibrios which took place in most cases within five days, though in one case they persisted for eight days. Dr. Crendiropoulo is careful to point out, however, that the limit of five to eight days must not be taken as the ordinary time of persistence of the vibrios, since they had probably been present for some time before they were discovered. In regard to the non-agglutinating vibrios, their frequency is found to be in inverse proportion to that of the agglutinating. They become more abundant as the carriers of true Cholera vibrios become fewer, but both of them cease altogether when the epidemic comes to an end. Dr. Crendiropoulo gives an interesting and exhaustive account of the bacteriological characters of the vibrios obtained, including their virulence for the pigeon, liquefaction of gelatin, coagulation of milk, the production of hæmolysis and the indol reaction; and he concludes that none of them can be relied upon as a criterion for the diagnosis of the Cholera vibrios. Even the fixation of complement and the agglutination reactions are not free from doubt. As a result of his observations, he suggests that every carrier of vibrios, whether agglutinating or not who comes from a place where the disease is epidemic, should be held as a suspect. The position as regards carriers may be summarised thus. It is generally persons, who have had an attack that become carriers. They do not remain so for more than 10 days in the vast majority of cases. Exceptionally periods upto two months have been recorded. The gall-bladder is supposed to afford lodgement to the bacilli which continue to be excreted therefrom at intervals.

For precautions to be taken to avoid Cholera during a fair, see " Sanitation of Fairs, etc., p 687.

INVESTIGATION INTO POSSIBLE CAUSES OF AN OUTBREAK.

On the appearance of Cholera in any part of a city, the methods adopted for the investigation of its causes are as follows :—

The name, age, sex, occupation, place of work and length of residence at present address are inquired into ; and the information sent daily to the Head Office by the Health Officers of districts.

The food-supply, milk-supply and water-supply and the possibility of infection from a former case either in the city or outside form the subject of inquiry.

If a case existed in the premises the water is examined, and if a well or tank exists, it is treated with permanganate of potash as a precaution. Each case is followed up, and the connection with a previous case ascertained, if possible, and all precautions are taken to prevent the spread of the disease.

Spot maps should be made showing each attack and death.

CONTROL OF CHOLERA.

The *measures for the prevention of the spread* of the disease are :—to notify the disease early, isolate the patient, disinfect or burn the stools and infected clothing, disinfect all utensils, boil milk and water, provide a pure supply of water and milk and food ; to protect the food from flies, disinfect houses and latrines, trace the cause of the disease, isolate convalescent cases, protect the water and milk supplies, immediately remove all refuse and issue printed instructions.

Fresh chlorinated lime powder in the proportion of two tablespoonsful to a pint of Cholera discharge is effective in 25 minutes. Strong izal 5 per cent. and carbolic acid 1-10 can be used for completely covering the discharges. For lime-washing rooms, $\frac{1}{2}$ lb. of chlorinated lime (bleaching powder) should be added to 7 gallons of lime-wash.

Cleanliness in the house and the removal of refuse and filth from the vicinity will help to keep away flies, and thus lessen the risk of the introduction of infection through their agency. Water should be boiled before use. Only freshly cooked food should be eaten. This measure will lessen the risk of infection from flies, which readily settle on food left exposed.

Sweetmeats or other food exposed in shops, swarming with flies, should not be eaten.

Raw vegetables, or unripe or over-ripe fruits, should be avoided as they are apt to cause Diarrhœa, and Diarrhœa predisposes to Cholera, by lowering the vitality.

Any symptoms of Diarrhœa should receive prompt treatment.

The above are measures which can be adopted in every household. In addition, there is an important preventive measure affecting a whole community in the disinfection of all sources of water by permanganate of potassium. This is a crystalline powder which, dissolved in water, colours it pink, the colour lasting for several hours. It is quite harmless to those using the water, but by destroying germs it prevents the spread of Cholera. The permanganate should be used according to the directions given. Bearing in mind the danger of contaminated water, and the risk of infection being carried by flies, special efforts should be made to keep the locality clean; people should be urged to go for natural purposes, away from tanks or streams. Warning should also be issued against washing soiled clothes near wells, or in tanks or streams from which household water is drawn.

The milk supply may be from the buffalo or cow direct, brought to the house door or kept in the compound. If the milking process is supervised by a reliable servant, the milk may be as pure as the animals can give it, but the *gowli* or milkman, his vessels, his family and domestic surroundings

require the strictest attention, if pure milk is expected. The milk may be from a dairy, or collection of milch cattle and the conditions under which they are kept and milked require all the supervision the authorities can provide. The milk may be from a small shop to which it has been brought and its composition and quality are likely to suffer during transit, or before distribution; this can be ascertained only by analysis; the water with which it is adulterated may be contaminated; the milk may come from a so-called up-to-date dairy in a large city, sent out in sealed cans or bottles; a periodic examination of even this supply and the dairy itself is necessary. The milk may come from a distance, by train or carried on the head of a cooly in open brass vessels, or by bullock cart, and may have to pass through many vicissitudes before arriving at its destination. All this points to a pollution of the milk before being consumed, and boiling is always advisable.

Anti-cholera inoculation.—This is a very valuable preventive measure and is specially indicated where continued supervision and enforcement of the ordinary anti-cholera measures is impracticable. The vaccine prepared in the usual way, is given subcutaneously in two doses of ½ c.c. and 1 c.c. each at an interval of one week. 1 c.c. represents 8,000 million bacteria. In emergencies a single 1 c.c. dose may be given. The immunity lasts about six months, *i.e.*, long enough to tide the individual over the dangerous period. No serious inconvenience follows the injection. Recent experiences have emphasised the very high value of inoculation as a preventive measure.

Bilivaccine—Attempts have been made to supplant inoculation by vaccine in tablet form to be taken by mouth. This is an improvement over the method of inoculation and as it has been highly spoken of, it may be tried when inoculation is not possible. Bilivaccine treatment confers immunity against cholera, which is said to last for about a

year. The treatment consists of one pill of bile to be taken on an empty stomach, followed quarter of an hour later by one tablet of vaccine. The vaccine tablet consists of 50 mgms. killed or dessicated vibrios, representing from 60 to 70 billions of microbes. The treatment has to be continued for 3 days successively. The merit of the treatment lies in its simplicity but the tablets are expensive.

Bacteriophages.—These ultra-microscopic organisms have lately been studied in connection with Cholera and Dysentery. In nature they are found in the intestinal tract and at times in water supplies. They also develop in cultures from diseased tissues and occasionally also in pure laboratory cultures. They are isolated by filtering a bouillon culture and planting a bit of the filtrate on an ordinary culture. If the bacteriophage (or as it is more conveniently called the phage) is present, the culture develops clear areas indicating the lytic action of the phage on the bacterium concerned. These clear areas contain the phage which can now be more easily planted from one culture to another. Repeated culture increases their virility till a maximum is reached and this is maintained for a considerable period. At times the phage dies out; this happens especially if the bacteria are present in overwhelming numbers. Sometimes resistent strains of bacteria persist and grow in spite of the phage being present.

The phage develops only in the presence of living and multiplying bacteria and never in media (natural or artificial) free from the germs. It also does not act or multiply in saline solution, but does so if broth is added. Traces of Calcium are necessary for its growth and action. It is very resistent. A lysed germ culture may contain the phage for years. It resists drying for several months and the action of chemicals for long periods. It persists in a strong solution of glycerine but is destroyed by heating for 30 minutes at 75° C.

Views about its exact nature vary but available evidence tends to show that it is more or less specific. It acts best on the organism from which it was isolated, acts less actively on bacteria of the same group and has no action on those of other groups.

In practice the Phage theory seeks to explain the recovery of individual patients and the gradual subsidence of an epidemic by the growth of the phage inside the patient's body and outside it in the material holding and serving to convey the infecting agent.

Thus it would appear that a cholera patient who excretes the vibrios in the earlier stages of the disease in his stools and may thus serve to infect a common water supply, later on and during convalescence begins and continues to excrete along with the vibrios the specific phage in gradually increasing amounts. The phage may thus be introduced into water supplies along with the vibrios during the later periods of an epidemic and becoming widely disseminated in the local population, confers immunity on it, itself gradually increasing in intensity and thus helping to stamp out the epidemic. According to this view, it would be undesirable to disinfect or sterilize water supplies especially during the later stages of an epidemic as this would destroy the beneficial phage along with the dangerous vibrios. This view is not universally accepted.

TREATMENT OF CHOLERA BY PERMANGANATE OF POTASH.

Whenever Cholera makes its appearance in a village, the water-supplies are purified by permanganate of potash. Permanganate destroys the germs which cause Cholera, and thus prevents the spread of the disease. Now it occurred to certain investigators that if permanganate could prevent Cholera by destroying Cholera germs in water, it might also cure Cholera by destroying the germs in a patient actually sick of the disease. It has been proved that if the drug is given properly, it has very good effects. For several years

past, the Government of Bombay has issued tabloids of permanganate free of charge for use in villages. Hitherto the tabloids have been dissolved in a *seer* of water. The patient receives only a small portion of the drug in relation to the amount of liquid swallowed, and as the stomach is very intolerant during Cholera, he often cannot retain it. Moreover, the drug has to do its work in the intestines and not the stomach, and for this purpose a pill is preferable to a soluble tabloid. The Sanitary Commissioner, therefore, has recommended that in future the drug should be stored in the shape of pills in all localities subject to epidemics, and promptly issued at the first appearance of the disease. He also recommended that the pills should be issued in 'treatments,' similar to the quinine treatments which have become so popular. Government have accordingly issued orders that the Civil Surgeons of districts and the Deputy Sanitary Commissioners should keep suitable stocks of permanganate made up into treatments of 24 pills, and these officers will supply them to Mamlatdars for issue, free of charge, in Cholera-infected localities. It will therefore be most important for village officers to report immediately to their Mamlatdars the first case of Cholera in their village and to obtain a supply of treatments for distribution. The Governor in Council trusts that they and all persons of education and influence will put forward their best efforts to popularize the use of the treatments and thus save many valuable lives. *Government Order, General Department, No.* 4289 *of* 25*th May,* 1915.

Essential oils mixture.—This is made up of Spirit Æther 30 ms., the oils of Cloves, Cajuput and Juniper, each 5 ms. Acid sulphuric Aromat, 15 ms. Dose for cholera patients 1 dr. every half hour with sufficient water till 8 to 10 doses are given. For contacts, one dr. with water once or twice daily during epidemic periods. The mixture is unpleasant to take and is not cheap. Very good results have been claimed for it.

Precautions to be adopted after the death or recovery of a patient.—Every article of bedding and clothing, the tapes or coir of the charpoy and the feeding and drinking vessels should be boiled for half an hour before allowing them to be washed, so as to destroy all germs. The floor and walls of the sick-room should be washed down with phenyle solution before being smeared with cowdung or limewashed.

Cremation or burial of those dying of Cholera should not be carried out near any source of water. Cremation should be most thorough, and burial at least 6 feet under ground.

Summary.—Cholera results from swallowing living organisms with food or drink. These organisms are easily killed by heat, and therefore freshly cooked hot food and boiled water can be safely used.

When Cholera is prevalent in an infected household, isolation of the sick, strict cleanliness and the free use of phenyle by the attendants, and disinfection by steam or burning of all infected articles will best prevent Cholera attacking other members of a family.

In an infected village, in addition to these precautions, disinfection of wells by potassium permanganate will check the outbreak. (For method, *see* p. 945).

The following instructions have been issued to taluka officers in the Bombay Presidency, for guidance on the outbreak of Cholera :—

(*Accompaniment to Government Order, General Dept., No.* 2290 *of* 18-3-1919.)

DUTIES OF THE MAMLATDAR DURING A CHOLERA EPIDEMIC.

1. Notification of infected villages to other villages in the taluka and to Mamlatdars of neighbouring talukas.

2. Send reports to Sub-Divisional Officer, Deputy Sanitary Commissioner and Collector.

3. Arrange, if possible, to go to the village with the Sub-Assistant Surgeon or send one of the Head Karkuns or some other senior Karkun if that is not possible.

4. Send out *at once*, by special messenger, if necessary, a stock of Cholera treatments.

5. Arrange for a trained man to go to the village at once to disinfect the wells, if well water is used for drinking.

CHOLERA INSTRUCTIONS FOR VILLAGE OFFICERS.

A. Explanatory remarks :—

1. The poison of Cholera is a very minute living organism : so minute that many lakhs of them could be placed on a silver two-anna one-piece.

2. This living organism multiplies in the body of the person suffering from Cholera, and leaves the body in the vomit and dejecta. The vomit and dejecta are therefore full of the poison of Cholera : *it is by them that the infection is carried from person to person.*

3. A person can only be attacked by Cholera if he swallows in his food and drink some living Cholera organisms.

4. Food, including milk, is contaminated by flies settling on it, or by the soiled hands of those who prepare it for use, or otherwise handle it.

Water in a river or tank is usually infected *by the washing of soiled clothes in it;* or by persons with soiled hands or feet washing in it or entering with cattle.

Water in a well is usually infected by soiled vessels being dipped in it or by washing clothes in the neighbourhood, so that some of the soiled water can trickle back into the well.

5. Cholera organisms are delicate and are *killed by heat* or by certain disinfectants such as permanganate of potash and chlorogen. *Hence* during a Cholera epidemic, people who drink only water or milk which has been boiled, and eat only freshly cooked food while it is still hot, will not get Cholera. *If food is allowed to get cold before eating, it may be reinfected by flies settling on it.* Flies sit on dejecta and vomit, and so carry filth directly to food.

6. The digestive juice of the stomach in its healthy state is slightly acid and destroys the germs of Cholera; but the eating of too much fruit or of any under-ripe or over-ripe fruit may destroy this natural power of resisting Cholera. *Hence,* during a Cholera epidemic *do not eat fruit of any kind,* and avoid sherbets.

B. What you can do to prevent your village from being infected ?

1. Do not allow any person from an infected village to enter your village. If this be impossible, do not allow any visitor from any village to go near any well or tank or river from which drinking water is taken. Arrange for some villager to draw water for the visitor and then pour it into his water vessel. Allow no visitor or traveller to wash clothes in the village except in a selected place.

2. *Advise* all villagers to boil all water and milk, and to eat only freshly cooked food while it is still hot, and to avoid fruit and sherbets.

3. Get the wells disinfected with potassium permanganate or chlorogen once a week, or as often as may be practicable.

C. What to do when cases occur in your village to prevent the infection spreading?

1. See that the sources of infection—the vomit and dejecta—are properly disposed of. The only safe way is to burn or boil all the vomit and dejecta.

(*a*) In some houses people may find it convenient to catch the dejecta in shallow earthenware vessels. In this case a vessel such as a kerosine oil tin should be kept on the fire with a little water in the bottom. The contents of the pan should be thrown into this. After a few minutes boiling the contents will be harmless and can be buried.

(*b*) If earthenware pans are not available or cannot be conveniently used, dry grass, dry leaves, sawdust or rags should be placed below the sufferer, and near his mouth. The soiled grass, etc., should be removed and burnt on a fire outside.

(*c*) In every case a wide mouthed vessel of boiling water such as a kerosine oil tin should be kept on the fire, and all soiled clothes should be thrown into it, and boiled for 15 minutes before they are taken to be washed in the ordinary way with cold water.

(*d*) The soiled ground below the patient can be disinfected with a strong disinfectant like phenyle. If no such disinfectant is available, soak the soiled ground with kerosine oil, crude oil or pesterine. This will prevent flies from settling on it. Then scrape away the soiled earth and throw the scrapings on the fire.

2. Allow no one from an infected house to go near the village sources of water for any purpose whatsoever.

3. Make arrangements to supply such persons with water. *The water must not be drawn with vessels belonging to them,* but with vessels kept for the purpose and should then be poured into their own vessels.

4. Allow no one to wash his mouth, body or clothes near any water which is used for drinking.

5. *Close temporarily all steps* to step-wells.

6. *In the case of draw-wells :—*

   (*a*) If possible keep separate vessels for drawing water, and do not allow people to use their own.

7. Select some wells for drinking water supply if there are many, and arrange for their regular disinfection: *once a day* while cases of Cholera occur if possible.

8. Advise people daily to use the selected wells, and have these wells carefully watched so that no one can wash himself or his clothes near them.

9. *When water is taken from a river :—*

   (*a*) Select one place for drawing drinking water or dig special budkis in the river bed.

   (*b*) Allow no one to wash himself or his clothes, water cattle, or perform funeral ceremonies near this place or upstream from it.

Arrange for these matters being done down-stream.

(c) Keep a watchman to see that these rules are obeyed.

10. Arrange for a man with a tomtom to go round the village daily to advise people to boil all drinking water.

11. Arrange, if possible, for the supply to houses from which cases have been reported of earthenware vessels, grass, vessels for boiling water and fuel for boiling water or burning dejecta, soiled grass, etc.

12. Send a special mahar *at once*, even if it is in the middle of the night to report the first case to the Mamlatdar.

The reasons for this immediate report are :—

(a) The Mamlatdar can inform other villages, so that they may take timely precautions to protect themselves.

(b) The Mamlatdar can arrange for some one with more knowledge and experience to visit the village for the treatment of the sufferers, and the prevention of the spread of infection.

(c) A large stock of medicines cannot be kept in every village. A small amount can be stocked for the first few cases, but the main supply must be stored at taluka headquarters. From this store more treatments can be sent to a village at once if a prompt report is sent to the Mamlatdar as soon as the first case occurs.

D. How to treat the sufferer ?

1. *Medicine.*—Give the friends at once a bottle containing potassium permanganate pills. Each bottle contains 24 pills, made up to the prescription of a doctor with very great experience in the treatment of Cholera.

One pill should be given every 15 minutes so long as the sufferer can swallow. The pills can do no harm if given at any state of the disease; they will do good if the stomach can retain them. Give the pills as early as possible : they are most valuable in the early stages. So advise people to report as soon as Diarrhœa commences.

2. *Diet* must be light : it should consist of milk and water or a conjee made of rice, jawari or bajri. This liquid diet should be given in small quantities—a mouthful or two at a time, and frequently—that is about every 30 minutes.

This weak diet should be contained *for some days after apparent recovery ;* fatal relapses are often caused by an injudicious and premature return to ordinary food.

3. *Drinks.*—The thirst in Cholera is usually very great: try to alleviate this by giving small quantities of cold boiled water, cold barley water, cold arrowroot water, or ærated water.

If ice is available, small pieces of ice may be given to the sufferer to suck.

Do not let the sufferer drink a large quantity at one time. A large draught excites vomiting and increases the thirst. Frequent sips will relieve thirst, large draughts will not.

4. *Pain.*—Try to relieve the painful cramps by hot fomentations and gentle massage.

5. If a hospital is near at hand arrange to remove the sufferer there at once.

CHOLERA LEAFLET FOR VILLAGE HOUSEHOLDERS.

A. Explanatory remarks :—

1. The poison of Cholera is a very minute living organism : so minute that many lakhs of them could be placed on a silver two-annas piece.

2. This living organism multiplies in the body of the person suffering from Cholera, and leaves the body in the vomit and dejecta. The vomit and dejecta are therefore full of the poison of Cholera : *it is by them that the infection* is carried from person to person.

3. A person can only be attacked by Cholera if he swallows in his food and drink some living Cholera organisms.

4. Food, including milk, is contaminated by flies settling on it, or by the soiled hands of those who prepare it for use, or otherwise handle it.

Water in a river or tank is usually infected by *the washing of soiled clothes in it ;* or by persons with soiled hands or feet washing in it, or entering it with cattle.

Water in a well is usually infected by soiled vessels being dipped in it or by washing clothes in the neighbourhood, so that some of the soiled water can trickle back into the well.

5. Cholera organisms are delicate and are *killed by heat* or by certain disinfectants such as permanganate of potash and chlorogen. *Hence,* during a Cholera epidemic, people who drink only water or milk which has been boiled, and eat only freshly cooked food while it is still hot will not get Cholera. *If food is allowed to get cold before eating, it may be reinfected by flies settling on it.* Flies sit on dejecta and vomit and so carry filth directly to food.

6. The digestive juice of the stomach in its healthy state is slightly acid and destroys the germs of Cholera ; but the eating of too much fruit or of any under-ripe or over-ripe fruit may destroy this natural power of resisting Cholera. *Hence,* during a Cholera epidemic *do not eat fruit of any kind,* and avoid sherbets.

B. How to protect yourself from Cholera ?

1. Never drink any water which has not been boiled.

2. Store boiled water in vessels which are cleaned every day by rinsing them with boiling water. Keep the vessels carefully covered.

3. Allow no one to dip cups in the vessels for storing water. If cups are used for drinking, they should be filled by pouring water from the storage vessels.

4. Never drink unboiled milk.

5. Do not lower your power of resisting infection by eating fruit or drinking sherbets.

6. Eat only freshly cooked hot food. Do not eat sweets and dried fruits bought in the bazar, and which may have been infected by flies. Every one must have seen the swarms of flies on sweets and other articles of food exposed for sale in shops.

7. Never eat uncooked vegetables.

8. Wash your hands carefully before eating.

9. Do not enter a house in which there is a case of Cholera.

10. Inform the Patel at once if you see an inmate of a house in which there is a case of Cholera near the source of the village drinking water-supply.

C. If you hear of a case of Cholera or Diarrhœa in the village inform the Patel at once.

D. What to do when a member of your house is attacked?

1. Inform the Patel at once.

2. Ask the Patel for a bottle of Cholera treatments, and start giving the pills to the sufferer at once.

Act in the same way even if you think it is only diarrhœa. The pills will do good even if it is simple Diarrhœa; for Cholera they are the best treatment possible if the patient cannot go to hospital or cannot obtain the constant advice of a doctor.

3. Keep all members of the household, except those actually required to attend the sick person, in a separate room or outside the house.

4. Every attendant on a sick person should be very careful to scrub his hands with soap and hot water every time he touches the sick person or anything soiled by him.

E. How to treat the sufferer?

1. Each bottle of Cholera treatments contains 24 pills made up to the prescription of a doctor with very great experience in the treatment of Cholera.

One pill should be given every 15 minutes so long as the sufferer can swallow. The pills can do no harm if given at any stage of the disease; they will do good if the stomach can retain them. Give the pills as early as possible: they are most valuable in the early stages. So advise people to report as soon as Diarrhœa commences.

2. *Diet* must be light: it should consist of milk and water or a conjee made of rice, jawari or bajri. This liquid diet should be given in small quantities—a mouthful or two at a time, and frequently—that is about every 30 minutes.

This weak diet should be continued *for some days after apparent recovery:* fatal relapses are often caused by an injudicious and premature return to ordinary food.

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4. *Pain.*—Try to relieve the painful cramps by hot fomentations and gentle massage.

5. If a hospital is near at hand, arrange to remove the sufferer there at once.

Sanitation of Places of Pilgrimage and Religious Fairs and Festivals.

There are several places of pilgrimage in India such as Hardwar, Benares, Muttra, Ambernath, Pandharpur, etc., where large fairs are held during certain seasons of the year. Hundreds of thousands of pilgrims congregate at these fairs and religious festivals, where an epidemic of water-borne diseases, chiefly cholera, frequently occurs. The sanitation of these fairs is therefore a matter of great importance, and at the same time, a very difficult task owing to the ignorance and filthy habits of the pilgrims. The waters of the sacred rivers and tanks at these pilgrim centres are seriously polluted by thousands of people bathing in them, and committing nuisance along their banks, and at the same time, such contaminated waters are drunk by them with perfect equanimity.

The principal sanitary provisions which are necessary at these fairs and festivals are, suitable accommodation in lodging houses or properly constructed camps, the employment of a sufficient staff of officers and men for supervision and inspection work and also for efficient conservancy, the provision of a pure supply of water and sufficient latrine accommodation, a sanitary police patrol to prevent the commission of nuisances, and the construction of a temporary hospital with the requisite staff, for epidemic diseases.

All lodging houses should be licensed and registered after proper inspection. Overcrowding must be prevented by fixing the number of lodgers to be accommodated in each house, which must at the same time be clean, well ventilated and drained, and have adequate water supply and privy accommodation. The camps should, if possible, be erected on a slightly elevated site so as to secure natural drainage, and they should be divided into separate sanitary areas in charge of one or more sanitary inspectors. Each area of the camp should be regularly visited to see that the men and women in charge of the latrines are keeping them scrupulously clean, and also to ascertain if there is any sickness, so that prompt measures may be taken for the removal and treatment of the sick to hospital.

The conservancy of the camps and latrines should be efficient. For this purpose, an adequate staff of male and female sweepers should be employed, and the number of carts for the removal of refuse and night-soil should be carefully reckoned, on the approximate number of pilgrims likely to be present. The floor of the latrines should be properly paved or cemented and drained, and each seat should have a bucket or iron receptacle. The walls of the latrines may, for the sake of economy, be made of bamboo matting. A liberal use of disinfectants such as carbolic powder, hycol solution, etc., should be made in keeping the latrines clean and free from flies. For the latter purpose, the application of pesterine to the floors and receptacles of the latrines is very desirable, because flies are potent carriers of the infection of cholera, dysentery and typhoid.

The latrines should be so located as to be easily accessible, and they should be lighted at night. In fact no latrine ought to be at a greater distance than one hundred yards from each camp, otherwise the pilgrims are likely to avoid the trouble of using them. As regards the number of seats, there should be one seat for every 50 pilgrims residing

in the camps. For people who merely visit the fairs daily, some accommodation is also necessary, and for them, two seats per 1,000 may be considered a sufficient average.

Where it is considered too expensive to provide regular latrines, the trench system may be adopted. A trench forty feet long, about a foot in width, and a foot or two in depth will prove quite convenient where the soil is firm. In sandy loose soil, the deep trench will have to be provided with boards and supporting cross beams to protect the edges of the trench from falling in by the weight of the user, and as many trenches of these dimensions as are necessary, should be provided. All refuse and night-soil are best disposed off by means of incineration in temporary incinerators. It is of the utmost importance that the pilgrims should not be allowed to pollute the banks of rivers or tanks or other sources of water-supply, but should be made to use the latrines. For this purpose a sanitary police patrol is necessary.

Every source of water-supply should be under proper supervision to guard against its improper use and contamination. If possible, filtered water should be distributed. If this is not available, deep tube wells should be dug. All wells and tanks should be treated with permanganate of potash, or better still, chlorinated. It is estimated that 15 pounds of bleaching powder containing 35 per cent. of available chlorine, will completely sterilize in about 15 minutes, a tank five feet deep and one acre in area. In all cases where such wells and tanks are used, a watchman should be kept to see that the vessels belonging to the public are not dipped into them for drawing the water, but mechanical arrangements should be made for the purpose. If river water is used for drinking purposes, its intake should be higher up the stream. On no account should the people be allowed to wash themselves or their clothes along the banks of such tanks or rivers. Funeral ceremonies should also be performed down the stream.

Arrangements should also be made for a market where the pilgrims could buy pure and wholesome food. Particular care should be taken of the milk-supply. There should be a sanitary inspector in charge of this market, whose duty it should be to inspect and destroy all unwholesome food, vegetables, and unripe fruit.

All these fairs should be under the direct supervision of the medical officer of health of the district. He should make all the necessary sanitary and medical arrangements. He and his staff should be on the alert to detect any cases of infectious diseases. A well-equipped temporary hospital should be provided near the fair for the treatment of patients. Wherever possible, ambulances for conveying the sick to hospital should also be provided. If it is not convenient to have ambulances, stretchers with gangs of coolies for carrying the patients should be kept in readiness.

In order to prevent an outbreak of cholera, it is very advisable to inoculate all incoming pilgrims with anti-cholera vaccine.

Small-pox and Vaccination.

The origin of Small-pox is involved in much obscurity. It is supposed to have had its origin in the East; certain it is that this very loathsome and fatal disease has been known in India for a long time. It was a disease from which almost every person born had to suffer and from which a large number of persons died or were disfigured terribly.

Definition.—A specific infectious disease due to an unknown virus and characterised by fever and a rash that passes successively through stages of papule, vesicle, pustule, crust, with a great tendency to subsequent scarring.

ETIOLOGY.

Incubation period.—Average 12 days. Extreme limits from 5 to 21 days.

Mode of infection.—Probably through the mucous membrane of the mouth, nose or respiratory tract. Infectivity :

greatest during the pustular stage of the eruption but starts from the very commencement of the disease and lasts till all the scabs have fallen off. The dried scabs are the main source of infection which stick to clothing, etc.

Quarantine period.—Not less than 16 days.

Characteristic initial symptoms are.—(1) Frontal Headache, (2) Vomiting, (3) Pains in the back. All three are often intensive.

The rash.—Appears first on the face, forehead, backs of the wrists and then spreads. It passes through the following stages—(1) Macule 3rd day, (2) Loculated vesicle becoming subsequently umbilicated, 6th day. (3) Pustule with a blackish scar in the centre, 9th day.

One attack usually confers life-long immunity.

Small-pox, as it occurs in the present day, may be divided into (1) Small-pox in the unvaccinated, and (2) Small-pox modified by vaccination. In both cases, after a person has contracted the disease, he may remain to all appearance quite well for eleven or twelve days; he then becomes feverish and sick, and complains of pain in the back for two or three days. Finally, the eruption comes out (usually first on the face), pimples which fill with clear lymph and then become pustules and form crusts. If the spots on the face run together, the disease is called confluent; if they remain separate on the face, the disease is called discrete.

Thus when a person has been exposed to infection, he should be quarantined for a clear fortnight. If he remains quite well, he may be regarded as safe. The patient is infectious from the very first symptom till all the scabs have fallen off. However, a case is rarely notified until the eruption appears and if then properly isolated, the spread of the disease is generally prevented. It has been found that if Small-pox were modified by vaccination, a patient treated in hospital would be free from infection five weeks after the

eruption began to appear; if the disease were not modified, a patient (provided he recovered) would not be free from infection until eight weeks after the eruption began to appear. As the particles, by means of which the disease is spread, are stored up in the crusts, these should be kept oiled from the time they begin to form.

Cases in which the disease is modified by good vaccination are often so mild that the whole eruption may not amount to a dozen spots. Such cases are particularly liable to escape attention. The head of the household may know nothing about them, and there is little likelihood of a doctor being called in. Yet infection communicated from such a patient, if the receiver be unvaccinated, may be as severe as possible.

An attenuated type of small-pox prevalent in certain countries has been named as Alastrim. It was believed at first to be a distinct disease from small-pox. The disease is characterised by high infectivity but low severity and is rarely fatal. It may, however, lapse at times into the more virulent type and prove fatal. In the mild form, the premonitory symptoms are milder and the rash may appear in successive crops on the same area, so that pocks of different ages may be co-existent. The vesicles vary in size but are uniformly round in shape and do not always show umbilication. There is no secondary fever at the time of pustulation of the pocks. Vaccination is said to be protective against the disease.

Inoculation.—The experience of the disease had shown that a person was not seized with it twice, that in a large percentage of cases one attack was protective against future attacks. In this experience is to be found the origin of the inoculation of Small-pox, a method consisting in inoculating the variolous matter into a wound on the body of a person previously untouched by Small-pox and thus giving him immunity from an attack of the natural disease.

The inoculated disease was found to be much milder than the natural disease and was therefore very willingly resorted to by the countries which suffered from Small-pox.

According to tradition, inoculation was a most ancient custom in India. It was practised by a particular tribe of Brahmins who, Mr. Holwell informs us, " were delegated from the different colleges of Binddobund, Benares, etc., over all the provinces. These divided themselves into small batches and arranged their circuits in such a manner as to arrive at their respective places of destination some weeks before the usual return of the disease." The Brahmins operated at the door, refusing to inoculate any who had not observed previously for a month the preparatory course of abstinence from fish, etc. Friction with a piece of dry cloth was made on the forearm or other part intended for inoculation; slight scratches with a fine sharp instrument were then made, but scarcely deep enough to draw blood; on this was bandaged a moistened pledget of cotton saturated with matter from the inoculated pustules of the previous year. The pledget was allowed to remain for six hours, after which the bandage was removed and the pledget left to fall of itself. The inoculated person was frequently douched with cold water over the head and shoulders upto the time of eruptive fever and the douches were resumed on the appearance of the pustules.

But inoculation had its own drawbacks. The method was not as safe as one could have wished and proved fatal in some cases; worse still, the inoculated disease was as infectious to the unprotected as the natural disease. It was, however, the milder of the two evils and continued to be practised in India till late.

VACCINATION.

In 1798 Edward Jenner published his inquiry into the causes and effects of variolæ vaccinæ and proved that a

person who had the Cow-pox, either accidentally or intentionally was not susceptible to inoculation of Small-pox and consequently was safe from the natural disease. He proved that it was possible to propagate the Cow-pox (or vaccinia) by inoculation after the manner of Small-pox inoculation first from cow to man and subsequently from one human subject to another.

VACCINATION IN BOMBAY.

The earliest record of vaccination available in Bombay pertains to the year 1849. But there is no doubt that vaccination was introduced into Bombay half a century earlier. History tells us that Jenner was very anxious about the introduction of vaccination in India. In 1799, about the end of the year, he sent copies of his works and a quantity of vaccine on board the "Queen", an East Indiaman, but the vessel was unfortunately wrecked on the outward voyage and the object frustrated. Jenner renewed his attempt; but the lymph was transmitted on lancet points or by means of threads soaked in the virus; but the length of the voyage and vicissitudes of climate for a time rendered futile all attempts to diffuse vaccination in the East. Eventually the genius of Jenner triumphed; for he secured the services of series of volunteers who were successively vaccinated during the voyage. Cow-pox was thus transmitted from arm to arm until it reached Ceylon and India. In the meantime, a supply of lymph had entered India from another source through Bombay; for in the spring of 1799, Dr. Pearson sent to Dr. Decarro, a Genoese by birth, then settled in Vienna, a supply of lymph upon threads. Decarro vaccinated successfully with it and in turn sent some of his lymph to Thomas Bruce, Earl of Elgin, who was then British Ambassador at Constantinople. He, with the courage of a Wortley Montague, first vaccinated his own son and then transmitted some of the lymph to Bombay, where the practice spread. The new method was at first opposed by the

inhabitants, but their objection was in part overcome by a "pious fraud". Mr. Ellis of Madras composed a short Sanskrit poem on the subject of vaccination. It was inscribed on old paper to give it an air of antiquity. In the Bombay Presidency, impetus to the work was given by the Honourable Mountstuart Elphinstone, Governor of Bombay, 1819-1827. The province was divided into four divisions, a European vaccinator being in charge of each division. Arm to arm vaccination was practised in Bombay till 1869, when it was replaced by animal vaccination.

The Bombay Vaccination Act of 1877 requires every Bombay-born child to be vaccinated within six months of its birth and every outborn person under 14 years within three months of his arrival in Bombay. Bombay was the first City in India to make vaccination compulsory.

The Registrar of Births sends a notice to the parent or guardian of the child directing his attention to the Vaccination Act, which requires the vaccination to be done within six months of birth, and mentioning the place and hour where vaccination is done free of charge on a certain day of the week. He also submits to the Superintendent of Vaccination, through the Executive Health Officer, a list of the births registered by him.

Bombay is divided into ten vaccination districts, each under a vaccinator. He is assisted by 3 or 4 karkuns under him, whose chief duty is to find out children for vaccination.

Each district has two or more public Vaccine Stations, where vaccination is done free of charge once a week. At some stations Vaccination is carried out every day. Every vaccinated child has to be brought at the same station next week for inspection by the Superintendent or the Head Vaccinator, when a certificate of successful vaccination is given. The date of vaccination of each Bombay-born child is put against its name in the register and notices are served against the rest as soon as they reach the age of six months.

PREPARATION OF GLYCERINATED CALF LYMPH.

Calf inoculation was started in Bombay in 1869, and the lymph was cultivated from calf to calf. The stock of lymph was at times renewed from the English lymph supplied by the Secretary of State and at times by retro-vaccination.*

Since the opening of the Vaccine Institute at Belgaum, preserved glycerine calf lymph supplied by it has entirely replaced lymph locally prepared in Bombay.

The preparation of lymph briefly stated is as follows :—

Healthy cow calves about a year old are kept isolated for 10 days. During this period they are bathed carefully in Arsenic solution on two occasions to kill off ectoparasites. If healthy at the end of this period, a calf has its belly shaved, washed with sterile water and then inoculated with stock vaccine by light parallel incisions with a sharp scalpel charged with the vaccine. During the next 5 days glycerine is applied to the developing vesicles and a bandage put on. On the 6th day the pulp of the vesicles is removed aseptically. To this a proportionate quantity of a faintly alkaline mixture of glycerine and water is added and the whole mixture is ground thoroughly by being passed between glass rollers four or five times. It is then subjected to the action of Chloroform vapour through an automatic aspirating machine for about 30 minutes. This kills off most of the extraneous organisms. The lymph is then sealed and kept under cold storage until required for issue. The whole process is done at as low a temperature as possible and under aseptic precautions. The lymph is also tested to see its bacterial contents if any. The few chance extraneous organisms that escape the chloroform are killed off by the action of the glycerine. For despatch out of Belgaum, the lymph is put up in small tubes wrapped in wet cotton wool and put in a wood box and corked and posted in a cardboard box inside a stout envelope. The

* Retrovaccination means vaccination from man to calf.

lymph is to be used as soon as possible after receipt at the station. It keeps potent for years under cold storage. A tube once opened must be used up at once.

In Paris, the lymph is diluted with an equal bulk of glycerine. In Brussels, twice the bulk of glycerine is added. In England, 5 to 8 times its bulk of 40 to 50 per cent. pure glycerine with distilled water is added.

VACCINATION OF A CHILD.

Age.—The best age is 3 months. In an epidemic it can be done on younger children but in these only 2 insertions are recommended. The outer surface of the arm should be washed with sterile water and allowed to dry. Acetone may also be used, as is done in Bombay with very good results.

Insertions.—With a lancet superficial incisions are made in the epidermis through 5 drops of the lymph previously placed on the two arms. These should be allowed to dry thoroughly before being covered. The lancet should be thoroughly sterilized after the vaccination of each person.

A papule is seen on the third day which turns into a vesicle on the fifth and a pustule on the ninth day with the margins raised, the centre depressed and the whole surrounded by a red areola. A crust forms on the eleventh day and drops off about the twenty-first leaving a smooth slightly depressed pale scar.

Constitutional symptoms are mild ; fever as a result of inflamation of the arm is usually present.

There are no dangers, provided the vaccinated part is kept clean and not disturbed. No dressing is required.

Post-Vaccinial Encephalitis.—Although cases undoubtedly traceable to vaccination have occurred in Europe, there have been none recorded in India.

Marsden and Hurst (Brain, 1932, Vol. 55, part 2, p. 181) affirm that encephalitis following vaccinia, small-pox, measles,

anti-rabic treatment and possibly cow-pox, mumps, and rubella, as well as certain cases arising independently of any known exanthem can be classified into one group as they clinically produce more or less the same symptoms, and pathologically the same lesions. This form of encephalitis differs from Encephalitis lethargica, poliomyelitis and rabies in that in the latter the primary attack is on the grey matter of the cerebrum and in the former on the white matter.

This proves that it is an independent disease which is merely activated by vaccinia Small-pox, etc., and not the result of some change in virulence or other property of the virus of the primary affection. Hence post-vaccinal encephalitis cannot be attributed to any error in preparation of calf-lymph.

Unsuccessful vaccination is chiefly due to defective technique or the use of inert lymph. It may also be due to natural immunity on the part of the child.

Re-vaccination.—Immunity from first vaccination does not last for more than 7 to 10 years; it is advisable therefore to repeat vaccination at the age of 10 years and also at 21 years.

In grave epidemics fresh vaccination centres should be opened in as many places as possible, vaccination being done even from door to door, if necessary.

Vaccination of persons exposed to infection.—The incubation period of Vaccinia being very much shorter than that of Small-pox, persons vaccinated during the first three days will escape Small-pox and those vaccinated as late as the fifth day will get it in a modified form if they at all suffer.

DURATION OF SMALL-POX IMMUNITY CONFERRED BY SUCCESSFUL VACCINATION.

There are two means of judging the duration of Small-pox immunity conferred by a successful vaccination. The first is through observation of those, who having had a

successful vaccination, are later exposed to Small-pox and the second, the duration of immunity to vaccination with vaccine.

It is well known that an occasional individual responds only slightly to immunizing agents; the degree of immunity established varies with the individual. The variable period that different individuals retain immunizing substances is also evident in all infectious diseases. This peculiarity is present for all anti-bodies. The enormous experience now gathered indicates that it is wise for any one exposed to Small-pox to be re-vaccinated, if a successful vaccination has not been obtained within nine months. The general population should be vaccinated about every five years, when Small-pox is at all prevalent. Even when the disease is absent, it is necessary that all persons be vaccinated in infancy and again in childhood so as to keep the population moderately immune and so prevent a sudden development of an epidemic.

The protection vaccination affords against Small-pox may be stated as follows:—

(1) That it diminishes the liability to be attacked by the disease.

(2) That it modifies the character of the disease and renders it less fatal and of a less severe type.

(3) That the protection it affords against attacks of the disease is greatest during the years immediately succeeding the operation of vaccination. A child must be vaccinated within six months of its birth unless—

(1) the parent obtains a certificate of exemption or (2) the child is attacked by Small-pox within that period or (3) three or more unsuccessful attempts at vaccination have been made or (4) a medical certificate of postponement is given on ground of ill-health. (Royal Commission on Vaccination, 1896).

How very severe Small-pox may be, those who have had long experience in connection with the disease can testify. There are two forms in particular that occur—the so-called "black Small-pox," where the eruption becomes dark from innumerable small hæmorrhages, and the variolæ sine variolis, where the disease is so malignant that there is no eruption but the skin is thickened and somewhat livid.

CEREMONY CONNECTED WITH VACCINATION.

The Indian community as a whole does not object to vaccination. Their indolence and apathy, however, come in the way of their getting children vaccinated early, unless the Vaccination Department compels it. This compulsion the Act allows to be applied. There are, however, a few prejudices connected with vaccination which it is worth while noting. Of these, the first is the religious aspect given to vaccination. The ceremony performed is the same as is gone through when a person gets the Small-pox. It consists in what is known as "naming" the disease, which is done when the vaccine vesicles appear. On this day a worship is commenced in a certain form with the burning of incense, a swing is provided with a number of neemb-leaf strings hanging above it and ladies of the house and neighbours and friends sit on the swing and sing in praise of God. This ceremony goes on for 9 days when the "vibhuti" ceremony is performed. This consists in applying "abir" to the pustules; the friends and relations of the family send presents of sweets and fruits to the child. From this day the disease is said to be on the decline, but the worship referred to above continues till the 21st day when the child is given a bath and taken to the temple of goddess Shitala, where the worship of the goddess is performed with great pomp and *eclat*. On the same day, friends and relations are invited to dine at the place. This ceremony is either much curtailed or even omitted by the higher classes of the Hindu community, but is still followed in detail among

Khatris, Kolis, etc. All this means expense and consequent delay in the vaccination of children. Second, a superstition generally noticed especially among Kolis is that no vaccination is allowed to be done in the locality where there are cases of Small-pox, as thereby goddess Shitala is believed to be much enraged.

EFFECT OF VACCINATION ON SMALL-POX.

The effect of vaccination on Small-pox will be seen by the comparison of the figures of mortality from Small-pox before and after 1877, the year when vaccination was made compulsory. The number of epidemics in the latter period is worth comparing with the number of epidemics in the former

BEFORE THE COMPULSORY VACCINATION ACT.

Year.	No. of deaths.	Year.	No. of deaths.	Year.	No. of deaths.	Year.	No. of deaths.
1850*	1,308	1857	346	1864*	1,707	1871*	919
1851	510	1858*	1,714	1865	567	1872*	1,854
1852*	1,003	1859	374	1866*	1,077	1873	714
1853	677	1860	166	1867*	1,055	1874	261
1854	232	1861*	1,627	1868*	1,123	1875	248
1855*	1,088	1862	163	1869*	1,725	1876*	3,174
1856	179	1863*	1,050	1870	556	1877*	958

AFTER THE COMPULSORY VACCINATION ACT.

Year.	No. of deaths.	Year.	No. of deaths.	Year.	No. of deaths.	Year.	No. of deaths.	Year.	No. of deaths.
1878	357	1887	108	1896	701	*1905	2,161	1921	406
1879	479	1888	482	1897	57	1906	276	1922	61
1880	207	1889	304	1898	55	1907	86	1923	479
1881	35	1890	150	1899	440	*1908	1,026	*1924	1,242
1882	92	1891	108	*1900	3,018	1909	473	1925	570
*1883	1,461	1892	541	1901	159	*1910	1,008	1926	480
1884	112	1893	201	1902	288	1911	443	1927	842
1885	55	1894	531	*1903	1,477	1912	979	1928	597
						1913	212	*1929	1,135
						1914	252	*1930	1,677
						*1915	3,599	1931	31
1886	19	1895	270	1904	556	*1916	1,021	1932	313
						1917	269		
						*1918	1,024		
						*1919	780		
						1920	294		

* Epidemic year.

In spite of the efforts of the Health Department to get all the children vaccinated, and to protect the City from Small-pox, epidemics of the disease, though on a much smaller scale than before, occur and the causes of these epidemics are as follows :—

(1) A certain number of births escape registration, and possibly these children are not vaccinated.

(2) Vaccination does not give a life-long immunity and in some countries, well-advanced in sanitation re-vaccination in later period of life is made compulsory. No such law exists in Bombay.

(3) Influx of unprotected persons from other parts of India, where vaccination is not carried out with the required vigour, and the difficulty of finding out such persons when they arrive in Bombay.

(4) The Hajis, most of whom are unprotected, were found to be bringing the infection from Mecca but the steps taken now to vaccinate them before leaving for the Haj have relieved the Health Department from one source of anxiety at least.

Duties of the Sanitary Authorities when a case of Small-pox is reported.

I. Isolation of the patient in an Infectious Disease Hospital or in a well isolated room with proper nursing at home, if the whole house is occupied by one family.

II. Vaccination of all those who have been in contact with the patient.

III. No convalescent should be allowed to mix with others till all scabs have fallen off and all ulcers in places like the nose, skin below the finger nails, etc., have thoroughly healed up.

IV. Infected articles should be burnt if of small value or thoroughly disinfected along with the room by fumigation, exposure to sunlight, steam, etc.

V. Attendants should wear overalls which should be disinfected after use every day.

VI. Corpses should be wrapped in sheets wet with strong disinfectant and if possible burnt. Burial should be done in lead-lined coffins made specially airtight.

Enteric or Typhoid Fever.

Definition.—A specific infectious disease characterised by continued fever, enlargement of the spleen and mesenteric lymph glands, ulceration of the Intestine and a rose coloured eruption.

Incubation period—from 10—14 days: (maximum 23 days).

ETIOLOGY.

Enteric Fever is due to the introduction of a special organism, Bacillus typhosus (Eberth), into the human body

This may occur in several ways :—

(1) Direct contagion.—This is possible in the case of persons attending upon typhoid patients or dealing with or handling infective or infected material such as fæces, soiled linen, etc.

(2) Infection of water supplies.—This arises through infected articles being washed in or near wells, tanks or by infective material such as excreta finding their way into them.

(3) Infection of food materials.—This may occur in several ways. Milk and milk products may be adulterated with infected water or stored or prepared in or dealt with in vessels washed with it. Salads and green vegetables may be similarly made infective. Oysters and other shell fish growing in polluted beds and ice prepared from infected water are other important ways of infection. Food material may also be con-

taminated by insects, mice, rats, etc., having access to both food and infected matter.

(4) Contamination of the soil:—This may lead to infection in 2 ways. Dust laden with bacilli may settle on exposed food stuffs or water. Bad sewers and cesspools and defective drains may lead to contamination of water supplies through leakage.

(5) Infection through the domestic fly:—The fly conveys the bacilli from infective matter such as fæces to food substances in 3 ways. 1. Mechanically, on various parts of its body such as the hairy legs, the proboscis, etc. 2. By regurgitating the already infected contents of its stomach on fresh human food. 3. By depositing dejecta containing the bacilli which have multiplied in and passed through its intestinal canal, on food material which may be kept exposed. This mode of infection played a very important part in the South African War.

(6) The great factor now is considered to be the "*human carrier*," that is, persons who have recovered from the disease and who may infect those with whom they or their excreta come in contact; this infection may last for several years.

There is little or no doubt that the 'carrier' commonly spreads the disease by means of his hands which infect food and drink. There is the greatest possible likelihood of soiling the fingers in the act of micturition, as far as males are concerned; though urinary carriers are more often met with amongst members of the female than those of the male sex. Similarly, some degree of soiling of the fingers is a very likely accident after the act of defecation, and it is on account of these possibilities that certain preventive steps must be

taken as far as the individuals themselves are concerned. For details about the subject of carriers. See p. 567.

Foster as a result of investigation in 387 cases of Enteric Fever, gives the following figures :—

> 30 per cent. due to infection from direct contagion, 38 per cent. due to infection from dust, food or water, 20 per cent. due to human carriers and the remaining 12 per cent. due to causes which could not be definitely determined.

There is comparatively little direct evidence as to the incubation period of Typhoid Fever. This is partly accounted for by its not being infective in the sense or in the degree that Typhus and Scarlatina are infective. Then the attack commonly comes on so insidiously, that its nature is not readily recognised, and the rash is scanty and not very distinct. According to Quain's Dictionary, the incubation is probably in most cases about twenty days. The range seems to be from one day to eleven weeks. It may be taken that the disease is wholly latent for about a fortnight; then there is loss of appetite, furred tongue, headache, pain in the limbs chilliness and regular rise of temperature from day to day. The spots may begin to appear on the fourth or fifth day, but not usually till the seventh day of the fever, or later. It is thus usually three weeks after the infection before the disease can be recognised and notified. The fever lasts from twenty-one to thirty days.

The regular chills, headache, and pains in the limbs may be absent, in which case diarrhœa will probably be the first symptom to attract attention. The signs of invasion in this disease are generally so indefinite that the patient often remains at his ordinary occupation for days after the temperature has begun to rise, and possibly does not consult a doctor

till a week has elapsed. About this time the eruption begins to appear, and continues coming out for at least a week.

During the third week the morning remissions of temperature are more marked, showing that the patient is beginning to improve; or less marked, indicating that the patient is sinking into a "Typhoid state". In the course of the fourth week and for a day and two after, if the patient is to recover and escape sequelæ, the temperature gradually falls to normal. If the patient continues well for a fortnight after defervescence, he may be discharged as there is no risk of his infecting others. Infectiousness in Typhoid commences with the first symptom.

A person who has been with a Typhoid patient may ordinarily, but not certainly, be considered safe after three weeks quarantine. If the person has been strictly clean, he has run little risk of being infected.

In Typhoid Fever, as in Cholera, all matters which the patient discharges from the stomach or bowels are peculiarly infective and, where suitable local conditions exist, can operate at a considerable distance from the sick. The patient's power of infection is ordinarily by means of these discharges, tainted food, air or drinking water; and precautionary measures should, therefore, be directed at preventing such contamination. The discharge thrown away without previous disinfection into a drain, cesspool or midden infects the excremental matters with which it mingles. The discharge also infects bedding, clothing, towels, etc., which it soils and renders, if not efficiently disinfected, liable to spread the disease to places where tne infected articles are sent to wash. It follows that by leakage from a drain or cesspool, or by castout slops or washing water, infective material may get access to wells or other sources of drinking water, and impart to enormous volumes of drinking water the power of propagating the disease.

When, therefore, a Health Officer is investigating an outbreak of Typhoid Fever he will bear in mind that the source of infection may be :—

(1) A polluted water-supply.

(2) Milk, directly polluted with discharges of the patient or to which specifically polluted water has been added for adulteration or for washing cans.

(3) Other food, shell-fish, directly or indirectly polluted with discharge of the patient. House flies may convey the discharge to milk and food.

(4) Clothes fouled with discharge of the patient. Such clothes may retain the infection for a long time—two or three months probably.

(5) A previous case acting as a carrier.

It is just conceivable that the source of pollution may be portions of discharge dried and carried in the air as dust. In any case the infection will not be conveyed far in this way. An imported Typhoid case will not serve as a source of infection if it is attended to in a proper and cleanly manner. However, to ensure this, initial cases should if possible be isolated in hospital, and great care should be taken in disinfecting and cleansing infected clothing, bedding, etc., and premises.

Disposal of carriers.—In the Army, the method of dealing with Enteric convalescents is as follows :—Examinations of urine and fæces are made on four successive days at intervals of a month. In the event of three of these monthly examinations proving negative, the individual is released from observation and all restrictions, though a final examination is made after a lapse of a further six months. If he is found to be a carrier after a period of observation (in England not exceeding three months), he is discharged from the service, unless he elects to remain in hospital for treatment. If discharged, notification is made to the Medical Officer of the

Ministry of Health and to the Medical Officer of Health for the district in which he intends to reside.

In investigating into the cause of an outbreak of Enteric, the following points are to be considered :—life-history of the first case; how long he had been living in the place where he was first attacked; if he had been exposed to the disease within three weeks, and if other cases had occurred, milk, food and water-supply and possibilities of their being infected.

In India the disease is so common and the movement of the people so constant and the distances so great, that much difficulty is experienced in tracing the origin of a case.

As this disease, in its mode of access to the body and the way it is propagated, so closely resembles Cholera, when Typhoid Fever appears in a district or its neighbourhood, it might be well to issue a circular to house-holders, similar to the one recommended in case of Cholera. In districts where basket privies are used and in any district, where practicable, a covered pail to receive excreta should be left at every house where a Typhoid patient is being treated. The pail should be charged with a disinfectant, changed daily, and the contents cremated.

Typhoid Fever, like epidemic Diarrhœa, is ordinarily most active during warm weather. As Spear remarked, in a report on an outbreak of Typhoid Fever at Pemberton, "There is much ground for the belief that the Typhoid contagion may lie dormant in the soil for prolonged periods becoming again active during the heat of summer."

According to the report of a committee appointed by the Clinical Society of London to investigate the periods of incubation, &c., "An epidemic due to milk contamination may be expected to cease at or about the end of the second week after the arrest of the contaminated supply; but an epidemic due to the contamination of a public water-supply

may not come to an end until the end of the fourth week after the source of specific pollution has been removed. Where an epidemic can be traced to well-water, its duration may be very much more prolonged and no general statement as to the probable date of the spontaneous termination can be made."

Food, milk and water at railway stations or *dak* bungalows, hotels and even private houses are so liable to contamination, that it is difficult to decide where the infection may have occurred.

A person convalescent from the disease may spread it, unwittingly; strictest precautions should therefore be taken in the same way as in the case of Cholera, and everything in the sick-room of an Enteric patient should be considered infectious. The nurses should not be allowed to attend other patients until after thoroughly disinfecting their clothes hands, &c. All bedding and clothing of an Enteric patient should be thoroughly disinfected, and so also all the utensils of the sick-room; while the strictest precautions as to disinfection of stools should be taken as in the case of Cholera.

Anti-Typhoid Inoculation.

Anti-Typhoid inoculation is now largely practised with good results; and has been brought to a high standard of efficiency in the British army.

A weekly return is submitted showing the percentage of strength protected by T. A. B.-2 and T. A. B.-1 methods and the number of inoculations performed during the week.

Extract from Army Order.

Home Force.

Anti-Typhoid Inoculation.

The preventive value of anti-Typhoid inoculation is now universally recognised; it has enormously reduced the inci-

dence of Typhoid Fever in the British, American and French armies and has been made compulsory in the two last named.

It should be practicable, by seizing every opportunity to inoculate the whole or a large majority of each unit. If a unit is likely to be stationary for a short time, advantage might be taken of this, with the consent of the General Staff, to inoculate a certain number of men, *e.g.*, a company or half a company, and in this way a whole regiment or other unit might be protected, without any serious interference with its duties.

In the same way individual men, temporarily disabled by minor ailments or otherwise available, might be inoculated.

Medical officers should lose no opportunity of introducing and carrying through some such system.

Dosage—Where time permits, the usual system of two doses, at an interval of 10 days, should be adhered to (*i.e.* ½ and 1 c.c.m. respectively), but if this is not possible a single dose of 1 c.c.m. (17 minims) will suffice.

It has been found by experiment that, after the single dose, about 60 per cent. of the men were fit for duty after 36 hours, about 90 per cent. of the men were fit for duty after 48 hours, and that 2.5 per cent., might still be unfit for hard work on the third day.

Simple surgical asepsis should be observed as to the syringe and needles and the arm prepared by a dab of iodine solution.

Should Typhoid make its appearance in a unit, special efforts should be made to inoculate all exposed to infection. Inoculation does not, in the opinion of Colonel Sir William Leishman, cause any increased susceptibility to infection, and any one inoculated in the incubation stage will probably have but a mild attack.

System of Record.

A record of inoculations is to be made on the top of the inside right-hand cover of A. B. 64 (Soldier's Pay Book) as follows :—

T.A.B.-2 or T.A.B.-1, with the initials of the Medical officer and the date or dates on which the inoculations were given.

T.A.B.-2 will indicate that the "two-dose" system has been followed, and T.A.B.-1 that the individual has only one dose of 1 c.c.m. of Anti-Typhoid vaccine.

Summary.—In the presence of an epidemic of Enteric, the disease is spread by infected food, milk or water, shell-fish &c., dust or human "carrier," infected hands or clothes, and conveyed by flies from infected latrines or trenching grounds.

The patient should be isolated, everything in contact with him disinfected, all milk and water boiled, and all food well cooked.

The house and food should be protected from flies, and any convalescent patient watched, the stools examined bacteriologically from time to time and disinfected ; special attention should be paid to the conservancy arrangements, and all horse and cattle litter burnt or buried ; the sewage from the village or cantonment should not discharge into a river, or near a water-supply. For instructions for disinfection see p. 960.

Prophylactic measures against the spread of Typhoid fever may be based on the following lines :—

A. Control of Epidemics :—

(1) Water supplies : These must be protected from infection and thoroughly supervisd wherever possible ; individual small supplies may be disinfected with Potassium

Permanganate. All drinking water should be boiled and no vessels which have not been previously washed with boiled water should be used.

(2) No food which has not been thoroughly cooked should be eaten. Milk should be thoroughly boiled before use. All food and drinks should be kept in fly proof cages or cupboards.

(3) Measures should be taken to prevent fly breeding and to destroy flies.

(4) Typhoid Carriers: A diligent search should be made for them and all Typhoid carriers should be prevented from taking any part in the preparation, or handling of food and drinks.

(5) Anti-typhoid inoculation:—This will not justify any laxity in the other measures advocated. It is specially indicated in cases of large masses of people subject to rapid variation in the conditions of life, as pilgrims, an army on the march, etc.

B. Prevention of direct infection from patient:—

(1) Stools, urine, and sputum should be received in disinfectants and kept for 2 hours before final disposal. The urinals and bed pans should be thoroughly disinfected.

(2) Feeding Vessels:—A separate set should be maintained for the patient and this should be sterilized at frequent intervals.

(3) Linen:—Should be soaked in 1-20 carbolic solution for 2 hours and boiled.

(4) Attendants should wash their hands very carefully after contact with the patient, special care being taken in this before taking food. Attendants on typhoid patients should take no part in the preparation or handling of food meant for others.

(5) Isolation of the patient in a hospital if possible or at the home under the supervison of a trained, competent nurse.

Yellow Fever.

A specific, usually very fatal, febrile disease occurring endemically or epidemically over a limited area of the Earth.

The chief endemic centres are the islands and coast of the Gulf of Mexico and the west coast of Africa.

Its centre is the West Indies, whence it spreads north to the United States and Mexico; south to Brazil. On the west it is seen on the Pacific Coast from the Gulf of California on the north to Peru on the south.

It has been seen in Spain, Portugal, Italy, France and Great Britain but has never succeeded in becoming firmly established.

ETIOLOGY OF YELLOW FEVER.

The cause is unknown other than the fact that it is a filterable virus which passes through the Chamberland F. bougie but not through the B. bougie.

This virus is contained in the peripheral blood of the patient only during the first 3 days of the disease.

Experiments have shown that this virus is destroyed at a temperature of 55 ° C.

If blood from a patient (in the first three days of illness) be injected into a healthy non-immune individual, the disease is reproduced in most instances, within the recognised limits of the incubation period, which may be taken as being usually 3—5 days with perhaps an extreme limit of 1½ to 13 days.

Further, blood from a patient infected by injection of blood from another patient on being injected into another non-immune will again reproduce the disease. Many attempts have been made to discover the germ of Yellow Fever and many organisms have been described. Up to the present it has not been satisfactorily identified.

METHOD OF SPREAD OF THE DISEASE.

For long the idea that Yellow Fever was transmitted by fomites prevailed. Experiments conducted by the American Commission showed that non-immunes could sleep and live in intimate contact with infected material, *e.g.*, black vomit, infected clothes, sheets and blankets, and yet not contract the disease.

It is now known that the disease is conveyed by a mosquito the Ædes Ægypti (Stegomyia fasciata). Further, only those mosquitoes which, have fed during the first three days of the fever are infective and they only become so after 12 days have elapsed since feeding on the Yellow Fever patient's blood. Before the expiry of this period, they are incapable of transmitting the disease.

The mosquito retains its infective power as long as it lives.

The French Commission verified the findings of the American one and in addition reported that—

(*a*) The infected blood will not reproduce the disease in a non-immune if merely laid on a raw blistered surface; it must be injected subcutaneously.

(*b*) Infectious serum if heated for 5 minutes at 55° C. loses its virulence but has prophylactic power.

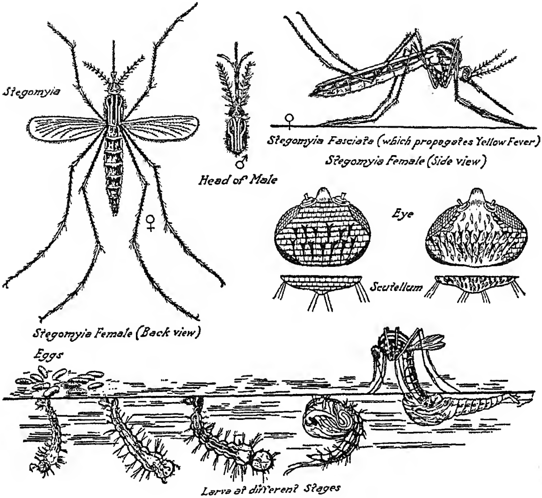
(*c*) Infectious serum loses its Yellow Fever producing power in 48 hours unless preserved under liquid petroleum, when it remains virulent for 5 days.

(*d*) Besides the method of hypodermic inoculation, Yellow Fever can only be transmitted by the bite of a mosquito in which the virus has lived for at least 12 days.

Owing to the very important part played by the Ædes Ægypti in the spread of this disease, it is desirable to give a few details of this mosquito.

STEGOMYIA FASCIATA.

(ÆDES EGYPTI)



No. 12.

This shows eggs, larvæ, pupæ and adult Stegomyia fasciata.

(l'Institute Pasteur de Paris.)

This species is widely distributed in the tropical and sub-tropical world extending from 38° N. to 38° S. latitude. (Bombay, roughly, 190 N.) It is rarely found at a greater altitude than 3,000 feet.

Stegomyia is essentially a domestic mosquito. It seeks the central and more crowded parts of the city. It is indeed a cistern-breeding

mosquito and is often known on this account as the *cistern mosquito.* It is found in abundance in those places where rain water is collected and stored.

The mosquito is readily recognised by the white bands upon the legs and abdomen and the lyre-shaped pattern in white on the back of the thorax. It is called the *tiger* mosquito. Only the females suck blood and they appear to attack man both during the day and at night, though perhaps they are more active between 5 p.m. and midnight.

CHIEF BREEDING PLACES.

Old tin cans, roof gutters, cisterns and various water utensils frequently seen in and near houses, *e.g.*, rain water barrels, buckets, flower vases anti-formicas, broken bottles, empty jam-jars, wells, etc., etc.

Each female lays between twenty and seventy-five eggs on the surface of water; these are minute, black and cigar-shaped; they are very resistant, and have been kept in a dry state for periods varying between 10 and 20 days; freezing does not destroy their fertility.

Under suitable conditions of temperature, the eggs hatch out in from 10 hours to 3 days. The result is the well-known "wiggle waggle" or 'wiggle tails," the larval stage of the mosquito. The larvæ are very active and sensitive, and rapidly disappear from the surface of water in the cistern if the least disturbance occurs.

For this reason, the water barrel or vat must be approached gently if one is desirous of obtaining specimens and examining them, otherwise they wiggle very rapidly to the bottom. Another point has also to be borne in mind, and that is that they cling to the sides of the receptacles and hide in the crevices, so that it is by no means easy to get rid of them. Simply emptying the water out of the receptacle will not suffice; a very thorough rinsing and cleansing is necessary.

The duration of the larval period is from 6 to 8 days normally; but they may remain in the larval stage for a much longer period. Sir Rubert Boyce brought some specimens alive from New Orleans to Liverpool, a journey occupying twenty-six days.

The pupal stage lasts two days or less.

Larvæ are always found in artificial water containers. The eggs may retain their vitality when kept dry for six and a half months. In searching for Stegomyia larvæ, the rain-water barrel is generally found to be the seat of election for breeding purposes. Given an old wooden barrel, just coated with a green slime, and "worms" will almost invariably be found: men accustomed to this work frequently affirm that worms must be in a barrel from its appearance. Yet a cursory examination of the water may fail to reveal their presence. When, however, the water is poured out all but a teacupful at the bottom, and this is well agitated, invariably

the larvæ are found. This habit of disappearing to the bottom of the receptacle and hiding in the chinks between the staves, and in the groove at the bottom is very characteristic.

They have been found in the blacksmith's shop in his cooling tank and also have been found in logs.

In living rooms and bed rooms they are frequently found in receptacle for holding flowers from which the water is imperfectly removed. Also in large ornamental plant pots enclosing the smaller or actual plant pot.

One does not encounter them breeding away from men: they are as domesticated as the flea and bug.

In a few instances they have been found in house drains mixed with Culex larvæ.

Their natural food is green algæ and diatoms.

ADULT MOSQUITO.

A black and white mosquito.

The *thorax* is ornamented with a curved silvery line on each side and two median parallel lines giving the characteristic lyre or few sharp pattern markings. The *legs and abdomen* are also banded, the hind tarsi are basally banded with white, the last tarsus being all white.

The *proboscis* is unbanded.

Egg-laying takes place chiefly at night.

HOW TO DISTINGUISH THE STEGOMYIA LARVÆ :—

They are longer than the larvæ of Culex fatigans.

Attitude.—Almost vertical.

Head.—Small.

Thorax.—Less conspicuous.

Antennæ.—Small and spineless and have a single hair about the middle, whereas Culex fatigans has large branched hairs.

Syphon tube.—Dark, short, stout and the syphonic index is 2. Worm-like wriggling is the mode of progression.

Pecton spines.—Two rows on the posterior aspect of the syphon tube.

Combs (scales) on the eighth segment at the base of the syphon.

The following table shows the differential characteristics of the eggs, larvæ and adults:—

—	EGGS.	LARVÆ.			ADULTS.			
		Attitude.	Breathing Tube.	Habitat.	Attitude.	Wings.	Bite.	Parasites.
Stegomyia ..	Float separately.	Float with head downwards.	Short and stumpy.	Tubs, pots, drains, gutter on roof, hole in a tree, hollows in rocks, broken glass on top of walls, and vases in cemeteries.	Parallel to the wall. Hunch backed.	Plain ..	Daytime.	Yellow Fever.
Culex	Egg rafts or egg boats.	Do. ..	Long ..	Do. ditches, cisterns: greater tendency to breathe on ground.	Do. ..	Do. ..	Evening	Filariasis.
Anopheles. ..	Separate, boat shaped, star-shaped pattern.	Float horizontally.	None ..	Terrestrial marshy soil with grass in water.	Angular, awl-like.	Spotted.	Do. ..	Malaria.

STEGOMYIA SURVEY.

The house, garden and yard should be carefully examined for breeding places, noticing particularly all water for drinking or washing inside and outside the house. Cisterns, barrels, buckets, tins, jars, tubs, goblets, anti-formicas, bottles, rain-water gutters of roof, etc. should also be examined.

These mosquitoes are prone to remain in the same house where they have been feeding. The French Commission succeeded in keeping a female alive for 106 days, but they consider that, under normal conditions, life is much shorter in duration than in captivity. To lay eggs the mosquito must first have a feed of blood, and the eggs are deposited on the surface of the water after about 3 days.

After the first egg-laying, the mosquito is believed to become more nocturnal in her feeding habits.

The various experiments of the American and French Commissions explain —

(*a*) The impunity with which a Yellow Fever patient can be visited by a non-immune if outside the endemic area.

(*b*) The danger of visiting the endemic area especially at night.

(*c*) The discrepancy between the incubation period (3-5 days) of the disease and the incubation period of the epidemic which may follow (13-15 days). This is due to the evolution which it is necessary for the germ to pass through in the mosquito.

(*d*) The high atmospheric temperature required for the epidemic extension of Yellow Fever. For its development in epidemic form, the virus of yellow fever requires a mean atmospheric temperature of 75°F. The disease ceases to spread when the thermometer sinks below this point.

(*e*) The clinging of Yellow Fever to ships, buildings, and certain areas (infected mosquitoes).

PROPHYLAXIS.

1. During epidemic visitations, non-immunes should, if possible, quit the implicated zone.

2. Slums and low-lying districts of the towns should be avoided; these places should not even be visited, or if visits must be paid, they should be as brief as possible and then always before sunset.

3. The susceptible persons should avoid sleeping in the lower stories of houses and pay great attention to their general health.

4. Sailors must not be granted shore leave. Ships should not be allowed to clear from infected ports, nor to enter non-infected ports during the warm season without adequate inspection.

If on entering port, Yellow Fever is found on board, the cases should be isolated in a quarantine hospital (where, if possible, there should be no Stegomyia mosquitoes), the ship thoroughly cleared of mosquitoes, and the passengers and crew segregated for at least 5, preferably 13 days.

5. In the event of Yellow Fever occurring in a locality which is not a Yellow Fever centre, and of which the population is small, a good plan is to remove every one except those in attendance on the sick and those who have had the disease previously, and place the deported population in quarantine for 13 days and in the meantime an extensive anti-mosquito campaign must be carried out.

6. It is of the utmost importance that there should be immediate notification of the first case, which must be followed by immediate isolation and screening of the patient by means of a mosquito-proof ward and bed curtains; if this is carried out at a very early stage, the risk of the disease spreading is much lessened; but it must be remembered that everything depends on promptitude.

7. ANTI-STEGOMYIA MEASURES—

(*a*) All unused receptacles of water must be emptied and no stagnant water allowed on the premises.

(*b*) All cisterns should be covered.

(*c*) Cesspools or privy vaults should be regularly treated with kerosine oil or with pesterine.

(*d*) The most thorough and careful search should be made for likely breeding places. (*q.v.*)

(*e*) Sleep under a mosquito net.

(*f*) Where possible doors and windows should be screened with fine mesh wire gauze. The hospital in which patients are treated should be so dealt with.

(*g*) Educate the public as to the mode of spread, and the breeding places of the carriers of this disease, by lectures, leaflets and placards and invite their co-operation.

EXTERMINATING THE MOSQUITO.

Sealing and fumigation—

Preparation for fumigation should be started with screening. The entire house must be fumigated. The rooms should be sealed from the inside with strips of paper. Stout paper may be used for covering large openings. Paper cut in rolls 3 inches wide is exceedingly useful for pasting along the cracks. Windows may be sealed from the outside in order not to disturb mosquitoes which may be present. The doorway is left open till the last to introduce the fumigating materials and to light up; when this has been done, the door is sealed and the time noted in a book kept for the purpose. The responsible officer should personally examine to see that the sealing is carried out effectively. A small open chink admitting light is sufficient to attract mosquitoes to it; then they make their escape. Halls, water-closets or out-houses must not be forgotten. After the allotted time necessary to complete the fumigation thoroughly, the doors are

opened and the floors swept. Some of the mosquitoes may only be stupefied, and it is necessary that they be all burnt or otherwise destroyed.

After the patient is convalescent, or after death, the patient's room should be fumigated.

The rooms should be carefully measured and materials proportioned to cubic capacities as under; small closets and ward-robes should be opened (Rubert Boyce):—

(1) *Pyrethrum Powder.*—Three lbs. to 1,000 cubic feet applied for 3 hours; it is better that the 3 lbs. be divided among 3 pots than that all the powder be put in one pot. The pots to be placed in pans containing a little water. Pyrethrum powder is used for rooms close to the sick patient, as the fumes which might escape from sulphur fumigation are irritating.

Pyrethrum powder is also used in cases where brass-work, pianos, telephone instruments, etc., are present.

(2) *Sulphur.*—2 lbs. to 1,000 cubic feet. The pots containing the sulphur are to be placed in pans holding some water. The burning of sulphur is to be started by alcohol, and care must be taken to see that it is well alight. Duration—three hours. Brass-work instruments and paintings are liable to injury; they should therefore be removed.

(3) *Camphor and carbolic acid.*—The mixture consists of equal parts of camphor and crystallised carbolic acid dissolved by gentle heat. It is an exceedingly good fumigator, does not injure furniture, clothes or brass-work, the odour is pleasant and smells of camphor. A room has a refreshing smell after its use. Four ounces are vaporised per 1,000 cubic feet for two hours; the material is placed in an open pan placed over a spirit or petroleum lamp; white vapour is given off.

It is most important that the houses in the vicinity of an infected house should also be fumigated at once.

The Government of India appointed a committee in 1919 to consider the question of preventive measures against the importation of Yellow Fever into India and the following are the recommendations of that committee :—

The Committee believes that at the present time yellow fever does not exist in India. Certain fevers, however, sometimes associated with jaundice and closely resembling yellow fever such as malaria, relapsing fever, and icterohæmorrhagic jaundice have been reported on a number of occasions in India ; it is desirable, therefore, that the cause and nature of these fevers should be carefully investigated whenever and wherever they occur with the object of differentiating them from yellow fever.

2. The prevalence of the mosquito S. fasciata, which transmits the yellow fever virus, and the existence of a susceptible population in the chief seaports of India, indicate that this introduction of the disease might be followed by sudden virulent epidemics. Such epidemics would be very difficult to control, would cause great embarrassment to coastal trade and maritime intercourse with foreign countries and would seriously interfere with recruitment and military movements at times of national emergency.

3. S. fasciata is present in India as in almost all maritime regions situated within the parallel 40° N. and 40° S. and all ports within such limits must be regarded in the present state of our knowledge as liable in varying degree to introduction of the disease and its dissemination. The degree of risk depends for the most part on the distribution of the disease at any selected time and on the sanitary condition of the threatened area especially with regard to the prevalence of the mosquito, stegomyia fasciata. At the present time the danger is greatest in—

(*a*) such ports on the American seaboard (including the Amazon) lying between the parallels of approximately 22° N. and 22° S. as are not subject to effective sanitary control of the disease ;

(*b*) ports on the West African coast from 15° N. to 15° S.

4. The danger to India at the present time is remote, but the risk will be increased *pari passu* with the extension of the disease to ports nearer India.

5. (*a*) The protection of India from the introduction of dangerous epidemic diseases depends primarily on a system of early notification of the outbreak of such diseases in ports which are in maritime relation with India. Such notification from ports in Asia, Australasia and Africa should be telegraphic, and the Committee recommends that this system be adopted as soon as possible.

(b) A central public health bureau in India to collect and collate information regarding the prevalence of dangerous epidemic diseases in countries outside India and to disseminate this information to all public health authorities in India is very necessary.

6. In view of the danger to India that would result from the extension of infection from the existing endemic areas in W. Africa to the ports on the east coast of Africa and of the increased likelihood of this on the completion of the transcontinental railway, the Committee considers that systematic efforts to stamp out yellow fever from the endemic areas in W. Africa would materially reduce the risk of infection reaching India.

7. As the safety of India depends largely on the freedom from yellow fever of ports intermediate between India and the endemic areas, it is desirable that the Governments of countries threatened by the possible extension of infection should come to a general agreement as to measures, particularly anti-stegomyia operations, which are necessary to render their ports free from the possibility of the establishment of the disease. Further, in addition to the establishment of an adequate system of inter-notification of dangerous epidemic diseases, it is desirable that information should be exchanged in regard to the actual sanitary condition of all ports (including shipping) with which India is in maritime relation, and of the progress made from time to time.

8. The Committee has passed unanimously the attached port health regulations, in the drawing up of which it has been guided by the provisions of the Paris Sanitary Convention of 1912. The main departure from the Convention consists in the addition of the words "or if it has lain at an infected port within 18 days of arrival" to the definition of a suspected vessel.

In the light of existing knowledge it is not possible to lay down the exact period of time during which a ship exposed to invasion by infected mosquitoes must be considered to be a source of danger. Pending more complete enquiry the Committee does not consider it advisable to make this less than the eighteen days generally recognised as necessary to detect cases arising from infected mosquitoes that may be taken on board at an infected port. This brings the modified regulation into line with the definition of the Paris Convention that a place shall not be declared free from yellow fever for 18 days after isolation, death or recovery of the last case of yellow fever.

9. The Committee is of opinion that the existing arrangements in the main ports of India are wholly inadequate to prevent the introduction of dangerous epidemic diseases, and considers that at each of the important ports of ocean call a sanitary station should be established providing facilities for—

(a) moorings for infected or suspected ships;
(b) the isolation of the sick and observation of persons who do not receive pratique;
(c) fumigation and disinfection.

As article 42 of the Paris Convention lays down that "every country must provide at least one port on each of its seaboards" with such facilities, the Committee recommends that in accordance with this article, the minimum immediate requirements of India necessitate the establishment of such fully equipped stations at Bombay, Calcutta and Rangoon. The Committee thinks that consideration should be given at once to the possibility of increasing the number of ports so equipped. If it should be found impracticable to equip fully and at once a larger number of ports than specified, it is still desirable that less elaborate schemes should be formulated and that those schemes should be so planned as to be capable of ultimate expansion. Having regard to the facts that with a voyage of 18 days' duration ships may enter the ports of India from a considerable portion of the eastern hemisphere, and that it is by no means impossible that some port or ports in this area, and on the East African coast in particular, may at any time be notified as infected, it is essential that the possibility of all Indian ports being ultimately called upon to deal with yellow fever infected ships should be borne in mind.

10. The Committee is of opinion that no possible advantage is to be gained from the establishment of sanitary stations on islands distant from the ports they have to serve. Moreover, stations of this kind would prove to be most unsuitable because (*a*) few islands can be found which are so situated as to be free from danger to shipping during the cyclone season; (*b*) the enforcement of the regulations would necessitate the detention of the ship for at least seven days which would seriously interfere with trade; (*c*) any measures short of observation for the full period would involve the risk of cases developing during the voyage between the island station and the port of destination and render necessary a second station at the port of destination or a return for further treatment at the island station.

11. (*a*) In recommending sites for sanitary stations, the Committee has given consideration to—

(1) possible interference with navigation of vessels;

(2) convenience of access so that there is the minimum delay to shipping and inconvenience to passengers;

(3) the safety of the seaport town from infection from the sanitary station;

(4) the conditions and surroundings of the site itself so far as they affect the health of the inmates.

These points limit selection, and the Committee finds that there is but one site in each of the three specified ports which satisfies all requirements—*Butcher Island in the case of Bombay*; the Rajabaria site in Calcutta; and the present segregation camp in Rangoon—and strongly recommends the acquirement of these three sites for the establishment of sanitary stations.

(b) Butcher Island is at present occupied by a wireless station and an ammunition depot. The Committee considers that, although immediate removal is not essential, arrangements for their removal at the earliest possible time is desirable.

Comparatively small alterations and repair of the existing buildings would fit the island for early use as a sanitary station, provided plans are completed for the rapid extension of accommodation should this appear likely to be necessary and measures are taken to reduce stegomyia infestation to a minimum. The Committee considers that the details should be worked out locally.

(c) The selection of the Rajabaria site for a sanitary station capable of dealing with yellow fever infected ships, is, in the opinion of the Committee, contingent on the acquirement in the first instance of sufficient land. The Committee recommends that the whole river frontage between the Indo-General dockyard and the South Union Jute Mill to a depth of about 440 yards be acquired. Extensive clearing of the land is necessary with a view to the carrying out of measures for keeping the area as free from the stegomyia mosquito as is possible. Plans for the necessary building are being prepared locally and should be completed as early as possible.

(d) The site on which the segregation camp near Rangoon now stands is low-lying and unsuitable for buildings. The Committee considers that reclamation is necessary, and that the area to be acquired and reclaimed should extend from the match factory to the telegraph hut, and to an average depth of 600 yards from the river frontage. The whole of this area would not be required for the buildings in connection with the sanitary station, but the Committee is of opinion that it is advisable to acquire and reclaim sufficient land to secure an area free from buildings around the sanitary station and to insure its freedom from mosquitoes.

(e) The Committee considered in detail alternative sites for all three ports. In Calcutta owing to difficulties connected with navigation, there is no alternative site which can be utilized for a sanitary station intended for all epidemic diseases, including yellow fever. In Bombay there is one alternative site, a portion of Hog Island, but the selection of this would lead to inconvenience to passengers and delay to the shipping, and there is also a possibility that malaria might become a serious factor. In Rangoon a good site could be secured at Elephant Point for dealing with yellow fever ships only; but the treatment of vessels infected with other diseases at this site would involve grave inconvenience to shipping, while the absence of good communication with Rangoon by road or rail presents a serious difficulty which could only be met by heavy expenditure.

12. The Committee considers that the expenditure involved in fitting up a sanitary station will be materially reduced if arrangement be made with the sanitary authority concerned for the admission of persons suffering from epidemic diseases into the infectious diseases hospital maintained by that authority. The Committee is, however, of opinion that each

important sanitary station should include a protected building providing accommodation for four yellow fever patients, and a separate protected building for the observation of ten yellow fever suspects.

13. The previous resolutions have been drawn up after consideration of the suggestion to accommodate yellow fever cases, suspects and contacts in specially fitted up hulks. The Committee is of opinion that a land site is infinitely preferable, because the accommodation on a hulk is limited by the capacity of the hulk and is incapable of expansion at short notice to meet a sudden demand. Moreover, the expense in maintaining these hulks will be considerable and it is conceivable that they may be under repairs when an emergency arises.

14. In view of the possibility of Government deciding that sanitary stations should be established in the near future in connection with the ports of Madras and Karachi, the Committee recommends that the land sites necessary for these stations be acquired now. The Committee does not feel justified with the information at its disposal in making a definite selection, but it appears that in the case of Madras the selection will be limited to ground between Tiruvuttyur and Ennur.

15. (*a*) In addition to these five main ports there are on the coast line of India some 196 ports, 104 of which are in the Madras Presidency and 75 in the Bombay Presidency. In the case of some of these ports vessels, the majority of which appear to be sailing ships, trade with ports in the Straits Settlements and in East Africa. The Committee recommends that a sanitary survey of these ports, including accurate information relating to the trade relations of each and mosquito infestation be made at an early date. It will then be possible to decide to what extent these ports contribute to the risk of the introduction of dangerous epidemic diseases, especially yellow fever, to India, and what measures are necessary to meet such danger.

(*b*) The Committee also considers it desirable that the whole question of coastal traffic by ship between various Indian ports and estuaries requires careful investigation with a view to devising means for checking the possibility of the spread of dangerous epidemic disease.

16. The Committee is of opinion that the *most* effective method of protecting the ports of India from yellow fever is to keep them as free as possible from stegomyia mosquitoes, and that it is undesirable to separate the work required for the reduction of stegomyia from that of mosquito reduction generally. Mosquito control can only be carried out by a properly directed organisation working under a legally constituted sanitary authority. The Committee, therefore, recommends that Government legislates—

(1) to appoint a sanitary authority for each port ;

(2) to establish a properly directed organisation for the control of mosquitoes in each of the larger sea port towns ;

(3) to provide for contributions from Government revenues towards the cost of these schemes;

(4) to secure the efficient carrying out of these schemes in the event of failure on the part of any local authority.

The Committee recommends that Government require each local authority in the seaports to prepare schemes for the control of mosquitoes. For the sake of efficiency as well as economy it is desirable that adjoining local authorities should prepare a conjoint scheme. An essential feature in the success of a scheme is the appointment of a special officer for the control of the operations. When the scheme has been approved by Government, the local authorities will be eligible for the financial assistance provided by legislation. With a view to meeting technical difficulties which arise in the execution of these schemes and for guidance in carrying them out, it is very desirable that the services of the experts attached to the Central Bureau of the Central Research Institute should be placed freely at the disposal of the sanitary authorities. These officers should have power to inspect the anti-mosquito work carried on in the ports and port towns and will thus be in a position to advise Government on the progress and efficiency of the work. Should it become evident to Government that their contribution to any scheme is not being spent to the best advantage it shall be open to Government to assume control of the operations, the defaulting local authority still continuing to pay its share of the expenditure.

17. The Committee desires to endorse the opinion expressed in paragraph 22 of the Report of the Committee to consider Port Sanitary Administration in England, and to state emphatically that in the reduction of the infestation of vessels with rats reliance should be placed primarily on—

(*a*) properly organized rat campaigns on land;

(*b*) periodic fumigation of vessels with holds empty.

The Committee recommends that every vessel trading between India and European, American and Australasian ports be fumigated when the holds are empty once on every round voyage. It understands that some shipping companies at the present time have made arrangements for this procedure.

18. In connection with *the fumigation of ships*, and with special reference to the possible fumigation of ships with holds full for destruction of mosquitoes, the Committee points out that at the present time the only available machine is *the Clayton apparatus* for sulphurous acid gas, which cannot be used without damage to certain cargo. The Committee has read the note on fumigation with hydro-cyanic gas written by Lieutenant Colonel Glen Liston, C.I.E., but, pending the result of further experiments cannot express a definite opinion with regard to the general adoption of this method of fumigation. Whatever gas is used in the future for the fumigation of ships, the Committee wishes to lay emphasis on the necessity for greater attention being paid to the through ventilation of all holds.

Without through ventilation of the cargo it is impossible to fumigate efficiently a loaded ship. A note by Colonel Glen Liston on the ventilation of ships is attached.

19. (*a*) In resolution No. 15, the Committee has called attention to the number of coastal towns in India defined as ports in the schedule attached to the Indian Ports Act of 1908 and to the fact that some of these ports have trade relations by sea-going vessels with ports in the Straits Settlements and East Africa. Should these latter ports become infected with yellow fever in the future, the danger of unprotected ports on the coast of India in maritime relation with them does not need elaboration. It is clearly impracticable to provide sanitary stations at all these ports and the Committee is of opinion that Government should have the power to declare fully equipped ports as first ports of entry for vessels infected with dangerous epidemic disease. The Committee suggests legislation on the lines of the following sections of the Quarantine Act of the Commonwealth of Australia:

Section 13 (1).—The Governor General may, by proclamation,

(*a*) declare any ports in Australia to be first ports of entry for oversea vessels.

Section 13 (1-*A*).—The power to declare first ports of entry shall extend to authorise the declaration of a port to be a first port of entry for all oversea vessels from any particular place or for any class of oversea vessels.

Section 20.—The master of an oversea vessel arriving in Australia shall not, unless from stress of weather or other reasonable cause, suffer the vessel to enter any port other than a port declared to be a first port of entry.

Penalty.—Five hundred pounds.

Section 77.—A pilot shall not, unless compelled by stress of weather or other reasonable cause, conduct a vessel subject to quarantine into any place other than the proper place for a vessel so subject.

Penalty.—Fifty pounds.

Section 78.—The master of an oversea vessel who, knowing that any quarantinable disease exists on his vessel, suffers his vessel to enter a port other than a port declared to be a first port of entry, shall be guilty of an indictable offence, unless he proves that it was necessary for the vessel to enter the port for the purpose of saving human life.

Penalty.—Three years' imprisonment.

(*b*) Captain Froilano de Mello suggests that Foreign Governments possessing ports in India, which are not provided with sanitary stations equipped for the reception of patients suffering from yellow fever, should be asked to make special arrangements whereby vessels suspected to be infected with yellow fever and bound for one of these ports should be

forced to call at a port possessing an efficiently equipped sanitary station where it would be dealt with, before proceeding to its original port of destination.

20. The Committee feels strongly that the defence of India from the introduction of dangerous epidemic diseases depends primarily on the sanitary surveillance exercised over vessels during their stay in infected ports with which India is in maritime relation, and that if absolute confidence could be placed on the efficiency of this surveillance, and on skilled and reliable medical supervision throughout the voyage there could be considerable relaxation of the measures to be employed on the ship's arrival.

Bills of Health are designed to supply information relating to the sanitary condition of the port and of the vessel on departure but these Bills vary in form and in value. The Quarantine Act of the United State of 1893 authorises the President "to detail any medical officer of the Government to serve in the office of the consul at any foreign port for the purpose of furnishing information and making the inspection and giving the Bill of Health." The Paris Convention resolved that "the Governments should confer together with a view to regulate Bills of Health." Should such a system of mutual trust and assistance between nations be impossible it should be feasible within the British Empire. Failing such arrangement the Committee recommends that should yellow fever appear within eighteen days' sail of India, the action taken by the United States Government under the Quarantine Act of 1893 should be followed by the Government of India.

21. The Committee supports the suggestion of the Government of Bombay that section 6 of the Indian Ports Act should be amended so as to permit of the inspection of vessels and the taking of measures whereby the breeding of mosquitoes shall be prevented.

REGULATIONS.

A vessel shall be regarded *as infected if there is yellow fever on board*, or if there has been a case on board within seven days of arrival.

A vessel shall be regarded *as suspected if there has been a case of yellow fever* on board at the time of departure or during the voyage, but no fresh cases within seven days, or if it has lain at a port infected with yellow fever within 18 days of arrival.

A vessel shall be *regarded as healthy* if there has been *no case either* at the time of departure or during a voyage which has lasted at least 18 days and which has not touched at an infected port within 18 days of arrival.

1. There shall be *medical inspection of every vessel* which has started from or during the voyage called at a port infected with yellow fever.

2. In the case of *infected vessels the* following measures shall be taken:—

(*a*) The *sick shall be disembarked* under protection from the bites of mosquitoes, and shall be efficiently isolated.

(*b*) There shall be a visual and *thermometer inspection of all other persons* on board, and any person exhibiting a rise of temperature above 99·4° F. shall be treated as under (*a*).

(*c*) The remaining persons shall be disembarked and kept *under observation during* a period which shall not exceed six days from the time of arrival.

(*d*) The vessel *shall be moored at least* 220 yards from the shore, and from other vessels and harbour boats.

(*e*) The vessel shall be *fumigated for* the destruction of mosquitoes before the discharge of cargo, if possible. If a fumigation be not possible before the discharge of the cargo, the discharge of cargo shall be under the supervision of the Port Health Officer, and may be permitted if the persons employed in unloading are kept under observation during the discharging of cargo and for six days to date from the last day of exposure on board.

3. A suspected vessel shall undergo the measures laid down under 2 (*d*) and (*e*) before the granting of pratique provided that in the case of a vessel which, in the opinion of the Port Health Officer, has been efficiently fumigated at the time of departure from the infected port or subsequently, further fumigation on arrival shall be unnecessary.

2(c) Shall be applied in the case of all vessels which have been less than 18 days on the voyage provided that the period of detention of passengers and crew does not extend beyond the 18th day after departure from the infected port, and is subject to a maximum of six days under observation and provided that, if the vessel has been efficiently fumigated since last leaving an infected port, the period of observation shall count from date of fumigation.

4. A healthy vessel shall be granted full pratique subsequent to medical inspection.

A NOTE ON THE FUMIGATION OF SHIPS.

There are two important matters with which everyone who has to *deal with the fumigation of ships must be familiar*—(1) the division of ships into bulkhead compartments and (2) the ventilation of ships.

Bulkheads.—The term bulkhead is used indifferently for all vertical partitions in a ship. Bulkheads serve three useful purposes :—

(1) They serve as watertight divisions.

(2) They serve as fire screens.

(3) They serve as structural diaphragms.

Bulkheads must extend well above the sea level. Lloyds rule regarding bulkheads may be summed up as follows :—

Steamers under 220 feet in length require only a collision and after peak bulkhead the machinery space which is always enclosed between

bulkheads giving four or three according as the machinery is amidships or at the stern.

A steamer more than 220 feet long must have at least four bulkheads.

A steamer 285 feet long and under 335 feet must have five bulkheads.

A steamer 335 feet long and under 405 feet must have six bulkheads.

A steamer 405 feet long and under 470 feet must have seven bulkheads.

A steamer 470 feet long and under 540 feet must have eight bulkheads.

A steamer 540 feet long and under 610 feet must have nine bulkheads.

A steamer 610 feet long and under 680 feet must have ten bulkheads.

The Bulkhead Committee of 1912 have decided that no compartment in any vessel should be longer than 92 feet and that none should be shorter than 10 feet except the fore-peak in vessels shorter than 200 feet. As regards the sub-division of vessels to prevent the spread of fire the International Convention for the safety of fire at sea requires that in passenger vessels the hull above the bulkhead deck shall be divided by fire-proof bulkheads placed not further apart than 131 feet and that all openings in these bulkheads shall be provided with fire-proof doors.

As a general rule the watertight bulkheads cut off entirely the adjoining compartments so that to pass from one to another a man must go on deck and descend the hatchways. A direct communication may be established by fitting watertight doors in bulkheads. These doors can always be effectively closed. All ships, therefore, can be fumigated in section which are not generally longer than 100 feet.

Ventilation.—The arrangements for ventilating the different compartments of a vessel vary greatly. In high class vessels elaborate ventilating arrangements may be made, but in other vessels the arrangements may be quite elementary. Many cargoes are of such a nature as not to be affected by or themselves affect the condition of the air surrounding them and in such cases whether or not the holds are ventilated does not matter. Delicate cargoes, however, such as grain and fruit, which are apt to decompose, require a constant supply of fresh air for their preservation, particularly if they are to be long confined in the hold.

In cargo steamers at least one cowl ventilator is fitted at each end of each hold, the one serves as a downcast and the other as an uptake. In many cases two pairs are provided in each hold. If through ventilation of the cargo is required, one of the two ventilators must be extended to the bottom of the hold, for when both stop at the deck the fresh air choosing the shortest route to the outlet, passes straight fore and aft over the top of the cargo and leaves comparatively undisturbed air at the bottom of the hold; but this is rarely done for with most cargoes surface ventilation is found to be sufficient. Ventilation for bulk cargoes liable to heat such as rice is often provided by interposing in the midst of the bales or bags a sort of open work of tubes roughly made of wood about ten feet long by nine inches square.. These tubes are placed vertically and

horizontally at intervals among the cargo so as to allow air to pass in all directions. With grain and other cargoes requiring very thorough ventilation a trunk way having air holes in its side is led fore and aft at the bottom of the hold and a downcast ventilator is led into it so that the air passing along the trunk way and escaping by the apertures may be distributed all over the bottom of the hold; a similar arrangement has been adopted to distribute cold air in holds which carry frozen meat.

Our present knowledge of such important epidemic diseases as plague, and yellow fever goes to show that their spread to healthy ports can only be prevented if a ship and its cargo can be thoroughly fumigated. Through ventilation of the cargo (on some system such as that described above) is necessary if a ship is to be satisfactorily fumigated without unloading it. In the majority of ships a simple modification of the existing arrangement to effect through ventilation of the cargo could easily be devised. The attention of Government should be drawn to the fact that while rules have been made and are enforced for the ventilation of all parts of ship used by passengers or crew, no attention has been paid to the ventilation of those parts of a ship in which cargo is stored. While such rules are unnecessary for the preservation of cargoes, they are required in order that an infected ship may be fumigated without removing the cargo. The danger of communicating infection to a healthy port by an infected ship which cannot be fumigated before unloading is very great, and the cost of unloading a single ship for this purpose would more than pay for the constructional modifications of the existing arrangements for ventilating the hold to effect through ventilation of the corgo in many ships.

DANGER OF YELLOW FEVER TO INDIA.

With the development of air-traffic between India and other countries, India is faced with a new danger in the form of transmission of Yellow Fever from its endemic centre in West Africa. Sanitary Authorities in this country have to be on their watch so that the danger may not materialise.

The mosquito-vector of Yellow fever—Ædes—is present in large numbers in East Africa, Egypt, India and the rest of Southern Asia. If yellow fever once breaks its bounds and reaches the Western Shores of Indian Ocean, it will continue its destructive course unhampered throughout the tropical and sub-tropical Asia.

It has been argued that because this disease has never spread from the West to the eastern side of Africa, there is some unknown factor preventing this. The available

evidence is against this view, for there is no evidence of racial immunity except such as is acquired by races long resident or aboriginal in endemic areas. It has also been shown that mosquitoes taken from India to England act as efficient transmitters of the virus in the Laboratory. The probable explanation of restriction of Yellow fever to one side of Africa is that communication across central Africa has so far been infrequent and slow and in the centre there is high land with a relatively cold, dry climate which probably interferes with the development of the virus within the mosquito. These factors have therefore prevented the infected human beings and the mosquitoes from carrying the disease from West to East. But now, with air transport opening up new communications throughout Africa, it will not be long before it will be possible to cross the continent in 2 or 3 days at the most and thus bring infected mosquitoes as well as men in the incubation period of the disease, to countries so far free from Yellow fever. From Mombasa to India via Aden will be another 3-4 days so that it will be possible for a man to reach India from West Africa in a week's time. It is definitely stated by some that man is capable of infecting mosquitoes during the incubation period of the disease in addition to the first three days of attack. It is therefore clear that once air travel between India and West Africa is thoroughly established, it will be possible for an apparently healthy man, who is infective to mosquitoes, to reach India. The terrible implication of this needs no emphasis.

The menace has to be fought against. Total forbidding of the aerial traffic from infected countries seems to be the only preventive measure against importation of the disease but is not practicable. A more hopeful remedy lies in the inoculation of men with the fixed virus mixed with the serum of a recovered yellow fever patient which is said to confer a considerable degree of immunity. If this immunity is shown to be certain of production vaccination of all travellers by

aeroplane from infected countries to Yellow-fever-free countries would greatly simplify the precautions at present necessary.

Phlebotomus or Papatasii Fever.

This fever, which is often called "three days" or "sand-fly" fever, is caused by an ultra-microscopic or filterable virus.

This virus is introduced by the bite of the sand-fly (phlebotomus papatasii) and seems to be in the patient's peripheral circulation only during the first 24-36 hours of the illness.

Blood extracted towards the end of the second day and injected into a healthy person fails to reproduce the disease.

If the infective blood is filtered through a Pasteur filter candle F, the filterate can cause an attack just as well as the original blood, resembling in this respect Dengue and Yellow Fever.

This fever can be easily differentiated from Dengue Fever, which breaks out in epidemics which are more explosive in character. In Dengue, the infection courses swiftly through a community until almost all susceptible people have been attacked. In a few weeks its energy will have been expended. The rashes which occur in about 70 per cent. of the cases, and the greater severity of the pains, mark off this disease from Sand-fly Fever.

GEOGRAPHICAL AND SEASONAL DISTRIBUTION.

Algeria.—P. papatasii has been noted in Algeria, being widely distributed in the Mediterranean ports, in the oasis of the desert and on the high plateaus. In the coast towns, P. papatasii is most frequently met with in July, August and September.

On the high plateaus are found P. papatasii, P. minutus and P. periniciosus only in the first three weeks of September.

China.—Sand-flies are frequently found in northern China. May and June are the worst months and the flies are most numerous near old crumbling buildings.

Mediterranean Area.—The disease is widely distributed in the Mediterranean area, particularly in the coast towns of the Adriatic. It has been shown that the papatasii flies can be carried alive for long distances, *e.g.*, from Malta to London. The coasting mercantile and fishing fleets undoubtedly carry the infected insects from place to place and when conditions are favourable for their breeding, epidemics are started.

The severe earthquakes of Italy and Sicily have provided abundance of suitable breeding places in the ruined walls of the houses.

Africa.—It is of widespread distribution in Africa, abundantly present in the Ivory Coast and Senegal; also seen in the Anglo-Egyptian Soudan.

Aden.—The Sand-fly Fever of Aden is less severe than that of the N.-W. Provinces and the common fly found is the P. minutus, whereas in India the P. papatasii is the only one of importance. It is present throughout the year, though most abundantly in the months of May to October.

India.—Many stations on the North-West Frontier. The sand-flies are most numerous during the end of April and in May. Their numbers lessen in June and July and increase again in August and decrease in September and October when they disappear at the end of the latter month. The following varieties are met with in the Peshawar Valley: P. papatasii, P. minutus, P. molestus and P. babu. The incidence of the fever fluctuates in the same manner as the flies.

Cases have been recorded at Peshawar, Nowshera, Attock, Kila Drosh, Chitral. In the Punjab, at Kohat. In Bengal, at Dinapore. In Rajputana, at Neemuch and Mount Abu. In Bombay, at Hyderabad. At the Himalayan hill stations, at Gharial and Dalhousie, and at Lucknow. The disease also occurs at many other places in India.

South America.—Brazil, Peru, etc.

ETIOLOGY AND MODE OF TRANSMISSION.

The germ, which is ultra-microscopic and filterable is found in the blood of the patient only during the first 24 to 36 hours. The transmitting agent is a moth midge in India, the Phlebotomus papatasii. Representatives of the genus Phlebotomus are to be found in most tropical and sub-tropical countries. They are very delicate, exceedingly minute, yellowish greyish, or brownish, slenderly built insects that bite principally at night and that can easily pass through the meshes of an ordinary mosquito-net.

The P. *papatasii* is very hairy. The legs are long and slender. The body, antennæ and wings are thickly covered with short hairs. The proboscis is as long as the head and the lancets project beyond the labium. The leaf-shaped wings, are narrow and show all the three branches of the second longitudinal vein very distinctly. When at rest, the wings are uplifted. (See p. 752.)

The P. papatasii lays about 40 eggs, selecting for that purpose damp places such as the walls of cellars, of latrines, cesspools, crevices in walls, caves and embankments. The cycle of egg, larva and imago takes about one month in warm weather and in cooler two months or more.

The *larva* has 12 segments. On the under side of the anterior portion is a subconical retractile process crowned with bristles.

The *pupa* has a respiratory cleft on each side of the thorax, and possesses spines by which it anchors itself to the cocoon.

The female fly alone bites and does so chiefly at night. In the day time, cool, moist, shady places are selected to retire to. The insect is a persistent vicious feeder.

It takes from 6-8 days for the sand-fly to be infective, after feeding on a patient on the first day of the fever.

The duration of life of the imago is not known. It is difficult to keep it in captivity. Investigators have succeeded in keeping these insects alive for 50 days.

In the Soudan, the sand-fly has been found breeding among damp stones, bricks and tiles, in caves and crevices of stone walls.

They have been frequently found in sandy soil which cracks in drying, and into these cracks the pregnant female probably descends to lay her eggs on the damp earth below the surface.

The larvæ of Phlebotomus are killed by a comparatively short exposure to dry air; they are never found in dry or nearly dry earth. They require a moderate degree of moisture, protection from light, and the presence of refuse the debris of dead insects, decaying fungi and possibly insect and dejecta; but an excess of this material is harmful.

Bricks, stones, tiles and cement form their common breeding haunts. Main sewers and vent-shafts, drains, cellars and prison cells, decayed stems of the prickly pear, the empty shells of molluscs and roots of trees, all act as breeding places.

One attack produces immunity. The disease is almost never fatal.

PROPHYLAXIS.

Any likely breeding places should be inspected carefully and, if practicable, removed, *e.g.*, heaps of stones, tiles, refuse, etc.

Buildings in areas known to be the resort of sand-flies should have all doors and windows protected with fine-mesh wire gauze carefully protected from injury and the residents should sleep under fine-mesh muslin nets.

Owing to the extremely minute size, the almost flea-like habits of the adult insects and the enormous area over which the breeding places may occur, the problem is a very difficult one.

(1) Lt.-Col. Hale is of opinion that these flies cannot face camphor. He keeps four squares of camphor on his bed night and day and the mosquito curtain is left open. Just before getting in bed, he pulverizes a few small bits of camphor and sprinkles the bed with it.

(2) The use of *mulmul* nets. Ordinary mosquito nets are of no avail as these insects readily pass through the meshes and attack persons as freely as if nets were not used.

(3) Use of punkhas and electric fans. These repel the attacks if continuously and properly employed.

(4) Early isolation of the sick.

(5) Evacuation of the infected quarters.

(6) Use of mosquito trap for capturing these insects.

(7) Spraying with repellants. Formalin in 1 per cent. solution may be sprayed every day in dark portions and angles of sleeping apartments. Mosquito curtains may also be sprayed towards sun-set; nets treated in this way are said to repel the attacks of these insects.

(8) Major Crawford, R.A.M.C., uses the following as a deterrent :—

Ol. anisi..	ʒ i.
Ol. eucalypti	ʒ i.
Ol. terebinthini	ʒ ss.
Ung. Acid boric	ʒ i.

(9) Counter attraction :—

A brightly burning kerosine oil lamp appears to attract the flies more than a sleeping human being. Daylight is a most important factor in driving away the flies.

(10) All openings and fissures in walls should be carefully filled in with cement so as to prevent the ingress and egress of the flies. Complete destruction of the breeding grounds must be aimed at.

(11) Periodic fumigation of sleeping rooms with Sulphur or Crude tobacco, will kill the adult flies.

Diarrhœa, Dysentery and Sprue.

Diarrhœa, Dysentery and Sprue are intestinal diseases each due to a microbe, organism (bacterium) or parasite, gaining access to the intestines through the medium of food, water, milk, dust, &c., and a human carrier.

These diseases may occur in epidemics, especially Diarrhœa in childien during summer and autumn months, and point to infection through food, milk or water, dust, &c.

The infective material may be carried by flies from infected latrines or dirty utensils.

The same precautions should be taken as in Cholera: good sanitary arrangements, and immediate disposal of refuse and disinfection of the stool; water and milk should be boiled, and the food and vegetables should be fresh and well cooked.

Diarrhœa.—Klein attributes Diarrhœa to the Bacillus Enteritidis Sporogenes, which is found in dust and air, and fæces, milk and food.

The food and milk should be protected and the latrines disinfected, the larvæ and eggs of flies destroyed and clean cooking utensils insisted on.

Climate and change of food have a great effect on the intestinal canal of Europeans in India, and many people suffer from Diarrhœa as soon as they get to a hill station, but recover when acclimatised.

Infantile Diarrhœa is due to want of cleanliness and impure feeding, the food and milk becoming contaminated.

Epidemic Diarrhœa is almost always associated with increased temperature of the air and autumn changes, and the mortality is for the most part among infants and very young children; still there are records from time to time of epidemic Diarrhœa at various seasons (even in mid-winter) when those who died were not even chiefly little children. There is no means of computing the length of the latent period, but it is certainly short. The attack begins with pain in the epigastric region, or abdominal griping, with a slight rise of temperature, vomiting and diarrhœa. The stools show that there is intestinal catarrh, and some times contain blood. There is commonly thirst and some suppression of urine, a weak and frequent pulse, and often cramps, extreme prostration, and, it may be, collapse. The attack lasts from about three days to a week.

As epidemic Diarrhœa is intimately associated with conditions of filth which favour its propagation, it is the duty of the local authority and the householder to remove such conditions.

DIRECTIONS FOR FEEDING INFANTS AND PRECAUTIONS AGAINST DIARRHŒA IN INFANTS.

1. Infants fed by hand suffer in a far greater degree from Diarrhœa than do infants fed at the breast. This shows that infants fed by hand are infected by their food.

2. Mothers should endeavour to suckle their infants for nine months. To do so, and to keep in good health, they must have abundance of good plain food, and maintain regular habits.

It is cheaper and safer for the child that the mother should be well-fed and suckle the child than to have the infant fed by hand.

3. An infant should not be weaned during the warm months when Diarrhœa is prevalent.

4. If a mother cannot suckle her infant, she should rather rear it on cow's milk than on condensed milk. The condensed milks usually given to infants are not sufficiently nourishing. Especially during the warm

months, mothers should frequently pour out a little of the cow's milk used and taste it to see that it is fresh. When a mother is obliged to wean her child, she should always consult a doctor as to the way in which the cow's milk is to be prepared for the infant.

5. It is better to have definite rules for feeding.

All vessels and utensils used in feeding the infant should be kept scrupulously clean.

When the milk has been received in the morning, the mixture which the child is to have should be made up to last 24 hours and the sugar or anything else to be added should be added at once.

The mixture, as it is to be used, should then be brought slowly to the boil, preferably in a double-jacketed pan.

It should then be poured at once into a clean jug, which is to be covered with a clean cloth and at once placed in a basin of water as cold as it can be got. Should the water get warm, it should be poured out, and cold water substituted, in which the covered jug is again placed.

The clean bottle and teat are to be kept in a covered bowl or basin containing water which has been boiled.

When the child is to be fed, the clean bottle and teat are to be taken out of the basin, the proper quantity poured into the feeding bottle out of the jug which is at once again covered and once more kept in the cold water.

The teat is then put on the bottle with fingers which must be scrupulously clean.

The feeding bottle is then placed in warm water until, after shaking it is just comfortably warm when put on the back of the arm, and the child is then fed.

As soon as it is fed the teat is taken off the bottle, both teat and bottle are washed in plenty of hot water and soda, and both are put back in the cold boiled water for next time of use.

6. There is strong reason to believe that the infection of Diarrhœa is carried from house to house, and planted on food by house-flies. Now flies are partial to milk, condensed milk, bread (which contains on the outer portion a sugary matter), and also to sugar and syrup. Hence all these materials should be kept carefully protected from flies; this may be done by keeping these foods in a cupboard to which air might be admitted by a fine wire screen panel. Or a keeping cupboard may be made out of an old box with a well fitting lid, or even of a clean box turned upside down provided flies are kept out.

7. Flies are attracted to houses where there are crumbs of bread, particles of sugar, treacle, and dirt.

8. It will be seen how necessary it is for the safety of children to keep the house always scrupulously clean.

No infant should be kept in the same room as an older person suffering from Diarrhœa, or should be in charge of any person who has Diarrhœa or who is caring for another child suffering from Diarrhœa.

9. There is reason to believe that Diarrhœa is not infrequently contracted from placing the infant on the floor. Older children suffering from Diarrhœa infect the floor, or other members of the family carry in infection on their feet. The infant sucks its soiled fingers or clothes and contracts the disease.

An infant under 12 months of age should never be allowed to crawl on the floor.

In any case, the floor should be frequently cleaned and always immediately after it has been soiled.

10. There is reason to believe that Diarrhœa is often communicated through the common habit of rubbing the child's gums to ease them about the periods of teething. This dangerous habit should be given up.

The dummy teat also often gets soiled and may cause Diarrhœa.

An infant's gums should never be touched with the finger, a dummy teat should not be used, and the child's mouth should not be interfered with except under medical instructions.

11. Every object which the infant can touch with its mouth should be kept clean.

12. Should an infant not appear to thrive, a medical practitioner should be consulted and his advice carefully followed.

13. Any accumulation of an offensive character near a house, whether arising from defective drainage, from collection of *cutcha* improperly kept or from defective cleansing of privies and gullies, should be reported to the Health Officer of the ward or to the Health Officer of the City. Other deposits near a house will require to be removed at once by the householder.

14. The yards should be kept clean, and the drains flushed with a few buckets of water daily.

15. Ashes should not be allowed to remain about the premises nor should vegetable refuse be scattered. Tea leaves, cabbages, fish, potato-peelings, etc., should be burned in the kitchen fire. No liquid should ever be allowed to remain about the premises.

16. Where any offensive smell is perceived in or near a house, the cause of which cannot be ascertained and removed, complaint should be made to the Health Officer of the ward.

Dysentery.

Dysentery is a term applied to a group of diseases, of which the principal feature is inflammation of the mucous

membrane of the colon. Three types of Dysentery, correlated to three kinds of parasites, are now fairly well made out. They are :—

(1) Bacterial or bacillary or epidemic Dysentery due to the presence of Shiga-Kruse bacillus.

(2) Protozoal or amœbic or endemic. Entamœba Dysenteriæ (E. hystolytica).

(3) Sporadic, due to Bacillus Coli Communis and other causes. The epidemic form is due to impure water, wind-borne dust, fly-borne infection, personal uncleanliness or it is of latrine origin.

The spread of Dysentery is due to infected food, milk or water, or a human being convalescent from the disease introducing the infection into a community.

Measures for prevention should be taken on the lines indicated above: isolation of the patient, protection of the food and water and strict sanitation.

Sprue.

By the term *Sprue* is understood a peculiar and very dangerous form of chronic catarrhal inflammation of the whole or part of the mucous membrane of the alimentary canal, associated with disturbance of the functions of glandular organs subserving digestion.

It has been called "tropical Diarrhœa," Ceylon Sore-Mouth, Psilosis Linguæ.

The disease never appears epidemically and is not contagious.

It is a disease of similar nature to Dysentery; little is known about the special organism in connection with it, and the same precautions are necessary.

In the event of Diarrhœa or Dysentery appearing as an epidemic, the water and milk should be examined for pathogenic organisms, and the source of the supply inquired into.

The milk supply of India is such a constant source of danger that none should be used without boiling or sterilizing.

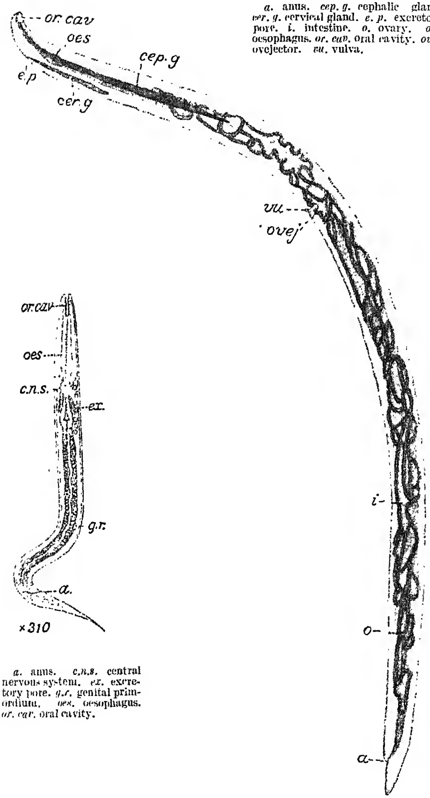
Ankylostomiasis or Hookworm Disease.

There are two species of hookworm infecting man, *viz.*, the Old-world type (*Anchylostoma duodenale*) and the New-world type (*Necator americanus*). Both varieties are common in India, particularly in Bengal, Madras and Assam, but the latter preponderates over the former species by nearly 80 per cent. According to Bentley, nearly forty millions of people in Bengal are infected with these worms, and in most districts four persons out of every five, have them.

The disease is widely prevalent in several parts of India, particularly in the plantations and coal mine districts. Similarly, it is also prevalent in French and British Guiana, the Southern States of America, Porto Rico and California. In these places, it is reported that the economic loss is very heavy, owing to the prevalence of the disease among the labouring classes.

The two varieties of hookworm resemble each other in their general appearance, life histories, methods of infecting human beings, and the serious ill-health they produce.

The adult worms chiefly inhabit the duodenum and jejunum, but occasionally they are found in other parts of the intestinal canal. The adult female is a little over half an inch in length, about the thickness of ordinary sewing cotton, and tapers slightly at both ends. The adult male is a little smaller in size. The head is similar to that of the female, but the tail end instead of tapering, expands into an umbrella-shaped sac which is useful in copulation. They are yellowish-white in colour, but being bloodsuckers, they naturally contain blood and then they are much darker in colour.



a. anus. *cep. g.* cephalic gland. *cer. g.* cervical gland. *e. p.* excretory pore. *i.* intestine. *o.* ovary. *oes.* oesophagus. *or. cav.* oral cavity. *ovej.* ovejector. *vu.* vulva.

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a. anus. *c.n.s.* central nervous system. *ex.* excretory pore. *g.r.* genital primordium. *oes.* oesophagus. *or. cav.* oral cavity.

Mode of Infection :—The development of the disease is remarkable. The life of the hookworm is made up of two periods. During the first period it lives in the soil, and the second period of its life is spent within the intestines of a human being. In the intestinal tract the worm lays eggs by the thousand. These eggs pass out in the fæces and favoured by heat and moisture, develop into minute larvæ in the soil in about three or four days. Under favourable conditions, these larvæ can live in the soil for even ten or twelve months, but they cannot develop beyond this stage, unless they gain entrance into the body of some human being and find their way into the intestinal canal. The ultimate goal of the worm being the upper part of the small intestine, the question arises how it finds its way there. The journey may in some cases be a short one, but in the majority of instances, it is long. The short method of infection is that the larvæ may be swallowed into the stomach and intestines by means of polluted water, or unwashed vegetables or fruit. But in 90 per cent. of cases infection takes place through the skin of the foot. In badly infected localities, and particularly in India, owing to the pernicious habit of the people to use the open ground as a latrine, the soil becomes so polluted with the larvæ, that it is almost impossible for a person to walk barefoot outdoors, without becoming infected. The larvæ have a most extraordinary power of attaching themselves to, and penetrating into the human skin. The first warning of this skin infection is a sort of dermatities, known as "ground-itch" or "cooly-itch." After they have thus burrowed into the skin, they enter the minute capillaries, and are carried by the blood stream into the heart and lungs. In the lungs the blood-vessels are too small to permit them to pass through, so they begin to burrow again, and find their way into the air-spaces of the lungs. Crawling along these, they reach the trachea and then the throat. Once there, they are swallowed with saliva and food and thus they gain entrance

to the intestine, where they fasten themselves to the mucous coat, and begin sucking the blood of the host. This long journey takes nearly two months to complete. In the intestines the male and female worms develop to adult life, and the females deposit numerous eggs, which being mixed with the excreta, are passed out on the soil, to spread the disease. It is said that each infected person will daily cast off with the excreta from one to four million eggs.

Effects of Hookworm Disease :—The infection is in most cases so insidiously acquired by the unsuspecting victim, that he and the members of his family, who are probably likewise being infected, have no idea as to when the effects of the disease began to manifest themselves. The outstanding symptom of the disease is anæmia. In the case of children who become victims of this parasite, their mental and physical development is greatly retarded, and puberty is delayed. In females, menstruation is frequently postponed or altogether suppressed, sterility is frequent, and still-births and miscarriages are common. In males it causes impotence. Among other common symptoms of this disease, there is dyspepsia, indigestion, and loss of blood, resulting in more or less profound anæmia. There is also œdema of the ankles, and in severe cases dropsy. The patient becomes very apathetic and disinclined for any work.

Preventive measures:—According to Bentley "the eradication and prevention of hookworm disease, requires a combination of measures; firstly, sufferers must be treated in order to expel the parasite; secondly, soil pollution must be prevented; and thirdly, people must be shown how to protect themselves from infection so that while the two former measures are in progress and even before they become effective, new infections may be reduced."

It is not the province of this book to describe the treatment of this disease. Suffice it to observe, that in oil of chenopodium and thymol, we possess two very efficient drugs for killing and expelling the parasite from the intestines. By

means of the microscope, we can readily diagnose the disease, and the treatment should be commenced as early as possible.

But treatment alone is not sufficient. The fundamental fact we have to recognize is that hookworm infection is due to pollution of the soil with human excreta, and obviously therefore to prevent the spread of infection, this pollution of the soil must be stopped. This is no doubt a difficult task in India owing to the age-long habit of the people easing themselves wherever they can. But this problem must be faced and met, by educating the public in regard to the dangerous nature of the disease, its mode of spread, and the simplicity of the measures necessary for its prevention.

The construction of adequate sanitary latrines, and the measures for enforcing the proper use of these conveniences, is a matter of prime necessity. Where there is drainage, proper water-closets should be provided, and in the absence of drainage, such water-closets should, if possible, be drained into septic tanks. The best and only way of preventing soil pollution is to provide sanitary privies and water-closets, which should be regularly used by all the people. The essentials of a sanitary privy are that it should be water-tight, it should have a fly-screened receptacle, the contents of which should be disposed of in a sanitary way, by burning, or trenching, away from any source of water-supply. It would also be a safe measure not to use human excrement as a fertilizer, as it is liable to carry hookworms to fruit and vegetables.

In regard to preventive measures, it is necessary to know a few facts in the development of the ova and larvæ of these worms. Dessication of infected soil will kill all the larvæ that may be present on it. In moist soil, the ova will develop very easily. It is said that if the excreta are diluted with water, to the extent of one part in 1000 or 2000 of water, the larvæ will perish and the ova prevented from developing. Larvæ may live in water for at least thirty days, and when encysted, for about five months. Sea water is

said to destroy the embryo as it emerges from the egg. Disinfectants are powerless to kill the ova. All this explains why hookworm infection is so common.

Lastly, the wearing of water-tight boots and even of wooden sandals is a great safeguard against the disease, and labourers in mines, plantations, and other places where the disease is common, should be encouraged to put them on.

Kala-Azar.

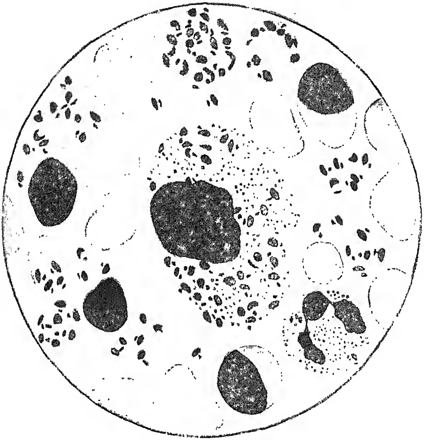
Kala-Azar is one of the diseases included under the term Leishmaniasis. It is characterized by an irregular fever of long duration, which may be rapid or slow in its onset. Associated with this fever there is progressive emaciation and enlargement of the spleen and liver, together with hyperpigmentation of the skin. A parasitic protozoon, *Leishmania donovani*, is present in the peripheral blood, spleen, liver, and bone marrow of patients suffering from this disease.

In India, it is widely prevalent in Bengal, Bihar and Assam, and to a lesser extent in the United Provinces, Madras and Orissa. Outside India, it is found in certain parts of China, Russian Turkestan, Spain, Malta and certain Greek islands.

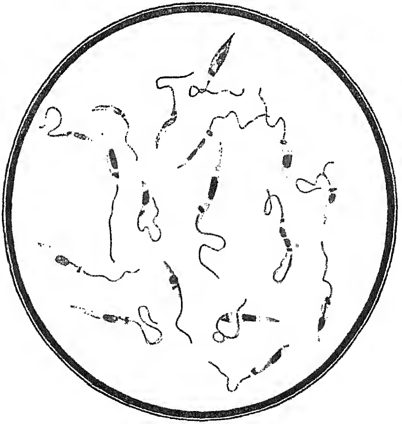
There is a Mediterranean type of the disease, in which the victims are almost exclusively infants and young children. This type is prevalent along the coastal areas of Italy and Sicily.

In his book on Kala-Azar, Dr. L. Everard Napier, of the Calcutta School of Tropical Medicine, states that there are certain factors which are common to all the areas in India where this disease is endemic. These are detailed under five headings, *viz.*, altitude, rainfall, soil conditions, temperature and humidity.

In regard to altitude, Kala-Azar is not endemic in any area which is 2,000 feet or more above sea-level. The normal annual rainfall in all endemic areas is above 50 inches, and as regards telluric conditions, the disease is almost entirely confined to alluvial soil. So far as temperature conditions are concerned, a monthly mean maximum temperature below



LEISHMANIA IN SPLEEN PUNCTURE SMEAR (after Knowles)



FLAGELLATE FORM OF L DONOVANI (after Knowles)

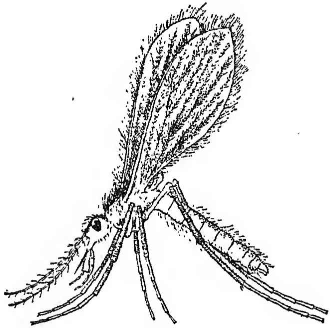
100° F., a monthly mean minimum temperature above 45° F. and a mean annual diurnal range of less than 20° F., and a diurnal range of less than 12° F., for at least three months of the year are common to the highly infected areas. The humidity factor is also said to play an important part in determining the distribution of the disease. "The common factor of the endemic areas appears to be a degree of humidity which is indicated by an annual mean of daily mean humidities of at least 60 per cent."

Etiology and mode of transmission.—The causative organism of Kala-Azar, as has been observed above, is a protozoon, called Leishmania-Donovoni, but its mode of transmission has not yet been positively ascertained. From analogy with other tropical diseases like Malaria and Trypanosomiasis, a number of insects have been suspected as possible transmitters. Paton had put forward a claim for the common bed-bug but there is convincing evidence obtained since then by different observers (including Paton himself) that the bug was not the offending insect. It was next suggested that since the dog constitutes the chief reservoir of infection in the Mediterranean area, the dog-fleas-Pulex Serrticeps and Ctenocephalus Canis—may be the actual transmitters. Workers in India have had uniformly negative results in transmitting Kala-Azar by means of the dog-fleas.

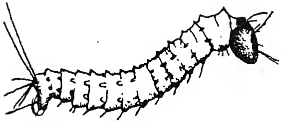
The work of Knowles, Napier and Smith at the Calcutta School of Tropical Medicine in 1924 pointed to a species of sand-fly Phlebotomus Argentipes—as the insect concerned in the transmission of the disease and this has been confirmed by the researches of the Indian Kala-Azar Commission (Second Report of the Kala-Azar Commission, India 1932). The Commission actually succeeded in transmitting the disease in one case by the bite of an infected P. Argentipes. One successful transmission does not however prove the claim of P. Argentipes, as the transmitting agent, as it has to be remembered that one successful transmission was obtained after a number of unsuccessful attempts, involving hard work for a number of years;

secondly, that in a case of Kala-Azar, the number of parasites circulating in the peripheral blood is not abundant to allow infection of sand-flies to take place on a large scale and lastly that the parasite is present in excretions like the urine and *fæces* of Kala-Azar cases. These considerations do not preclude the possibility of other modes of transmission besides the one under consideration.

Another mode of transmission suggested by the Commission is by the oral route. In their opinion, the claim



Adult.



Larva.

Egg.

SAND-FLY.

of this hypothesis is almost equally strong as that of the preceding one, since this view is backed by more than one successful transmission. The source of infective material will obviously be the urine and *fæces* of Kala-Azar cases. Besides it has been conclusively proved that susceptible animals can be easily infected by the oral route. May it not be that given the susceptible individuals and the infected material, the oral route may serve as the channel of infection in at least a certain number of the Kala-Azar Cases ? Future will decide this question, one way or the other.

A third possible method of transmission according to the Commission, is to combine the possibilities of the first and the second methods and to consider that P. Argentipes produces infection by the oral route. This view is supported by one successful transmission though it is admitted that the amount of work done in connection with this theory is not much. It is not inconceivable that P. Argentipes may be crushed near the mouth or its crushed remains transferred to the mouth from any site and so cause fresh infection. This theory occupies a lowly position and it will have to be investigated by future workers.

Transmission by hook-worm has been definitely ruled out by the Commission as a result of their investigations.

The work on Kala-Azar, which has been summarised above, has not enabled the Commission to decide upon the exact mode of transmission of the disease, though it has clarified the subject and narrowed down the issues. Future work will settle as to how the disease is propagated, whether by one or more than one agency. In the solution of this question, a possibility will have to be considered also that as in some other diseases, *e.g.*, Plague, there may be more than one method of transmission.

One further aspect of the subject must be considered in discussing the subject of Kala-Azar transmission and that is the importance of an accessory factor. The sandfly is

present in large numbers for the greater part of the year in epidemic areas and about 20 per cent. of the flies that feed on Kala-Azar patients are likely to become infected. Supposing that the method of transmission is by the bite of an infected P. Argentipes, it does not follow that the bite of an infected fly which inoculates a certain number of L. Donovoni will necessarily be followed by the appearance of the disease in the individual unless the accessory factor is also present, *viz.*, a condition of lowered resistance. McCombie Young (1924) has pointed out that the Kala-Azar epidemics of 1890-1900 and that of 1917-1929 were preceded or accompanied by events which had the effect of lowering of mass resistance. In one case it was an earth-quake, in the other, a pandemic of Influenza. The great difference between these two natural phenomenon leads one to suppose that the mass resistance may be lowered as a result of widely differing agencies. Among the most common of such agencies likely to affect individual resistance to disease, is Malaria, though Typhoid and other epidemic diseases may act in the same way and cause an increase in the incidence of the disease in the population of endemic areas.

Prophylaxis.—On the assumption that the sandfly is the transmitter of the disease, the preventive measures that would suggest themselves would be similar to those advocated against sandfly fever. Domestic and personal cleanliness and prompt removal of all refuse, bricks, stones, etc., where sandflies are likely to breed, should be resorted to. Periodic fumigation of sleeping rooms, with sulphur, or crude tobacco, will kill the adult flies. The use of *mulmul* nets and the placing of pieces of camphor in the beds are measures which would prevent the bites of these insects. For a more detailed description of anti-sandfly measures, the reader is referred to the article on *Phlebotomus* fever in this book.

In Assam, the two measures that have been adopted against this disease are compulsory segregation of the sick and

contacts, and treatment of the sick. For the latter purpose, a large number of dispensaries have been established in various parts of the province, in charge of specially trained doctors. In infected coolie lines on the tea estates in this province, wholesale evacuation and burning of infected huts and their contents have been resorted to, with some measure of success for the extermination of this disease. In recent years, the tendency has been to rely entirely on treatment, because in antimony, particularly in the pentavalent compounds of this drug, we possess a sure specific against the disease. In 1915, Sir Leonard Rogers introduced into India, the treatment of Kala-Azar by means of injections of sodium antimony tartarate. A cure rate of nearly 80 per cent. of the cases was brought about by this means. Since then a further advance has been made in the treatment by the use of Urea Stibamin which was first prepared and used by Dr. U. N. Brahmachari of Calcutta. It is claimed to be an eminently safe and reliable drug and the Kala-Azar Commission used it for over 7 years in some thousands of cases with remarkable success. It has been noted in connection with the use of this drug that whereas it is entirely successful in the acute fulminating type of the disease which is characteristic of the peak period of an epidemic, the same cannot be said about the more chronic type of the cases which are met with during the latter part of the epidemic. In such cases, it acts more gradually, requires a larger total dosage and yields a larger number of refractory cases. This characteristic of the drug is also shared by other antimony compounds, *viz.*, the sodium or potassium salts or the various other preparations which have been put on the market subsequent to the introduction of Urea Stibamin and as a result of its success.

In the Mediterranean area, Leishmaniasis in dogs and cats is frequently associated with human cases of Kala-Azar, and some observers have maintained that in Italy, the disease passes from dog to man. But so many cases occur

which cannot be associated with any infected dog, that it would appear that the infection of the animal is as much an accident, as the infection of the human being. On this account, one of the preventive measures recommended in these areas, is the destruction of infected dogs and cats. But such a measure in India does not appear to be necessary, because observers in this country have failed to produce infection in animals, and the canine disease is absent in endemic areas in India.

Beri-Beri.

A specific form of multiple peripheral neuritis occurring endemically, or as an epidemic, in most tropical and sub-tropical countries and, also under certain conditions, in more temperate latitudes. In countries where there is a hot and cold season, the epidemic outbreaks occur during the former. In countries hot all the year round, Beri-Beri may occur at any time; most frequently, however, during the rains.

It attacks both sexes. Although rare in childhood and extreme old age, it occurs at all ages, its favourite age being about 15 to 30.

It affects rich as well as poor, and is confined to no particular trade or occupation. If anything, it has a predilection for those who lead a sedentary life and are much indoors, as students, prisoners, inmates of hospitals and asylums. It is apt to attack pregnant or parturient females, and the breast-fed child of a Beri-Beric mother is apt to develop the disease. Over-crowding appears to favour the spread of Beri-Beri.

Unlike Malaria, Beri-Beri is common in the native crews, more rarely though occasionally, among the European officers and sailors of ships on the high seas.

The disease is usually described under two types : (*a*) a wet or dropsical Beri-Beri, in which the vaso-motor nerves are affected with resultant general œdema and (*b*) a dry, atrophic or paraplegic type in which muscular palsies and atrophies are the leading features. Mixed cases also occur in which there is a mixture of the above features.

Hamilton Wright classifies the cases as follows :—Acute Beri-Beri (Cardiac, Motor, Sensori-Motor or Vaso-Motor) and Residual (Cardiac, Motor, Sensori-Motor or Vaso-Motor) Paralysis.

ETIOLOGY.

Beri-Beri is now accepted as a disease of nutrition due to the absence of the water soluble B Vitamin from the food. The disease commonly occurs among rice eating races.

Rice is prepared for commerce either cured or uncured.

In the cured variety, the unhusked paddy (rice) is boiled until the husk splits, after which the boiled grain is exposed to the air until it is perfectly dry and is forthwith further treated or stored till required.

Uncured rice is rice which has been unhusked and polished in a mill. During this process the pericarp and more or less of the aleurone layer and the embryo are rubbed off and nothing but a polished white grain is left. When the process is continued until but little remains except the starch granules, the rice is termed polished, highly milled, or white rice; when the milling is less complete, the rice is known as under-milled or red rice.

In the case of cured rice, as opposed to the white rice the parboiling or steaming process causes the pericarpial and the aleurone layer to become, in part, adherent to the grain, and it is this layer and the embryo which contain the vitamin or anti-Beri-Beric element essential to the diet and this layer is not lost in the subsequent treatment of the rice for the market.

The cured, steamed or parboiled rice may be subsequently treated by milling or by rubbing in a mortar or by hand before being placed on the market. Rice grown in Bengal, the Konkan and the Malabar Coast is usually cured. Uncured rice is exported from Burma, Siam and French Indo-China.

In the process of preparing uncured rice, the scale-like dust found in the machines passes under the name of rice polishings and has curative value for those who have developed Beri-Beri under a diet of polished rice. Polished or white rice contains as a rule less than 0.4 per cent. of P_2O_5 while the Beri-Beri preventing rices contain more.

Funk, Fraser, Stanton, Eijkman, Braddon and others have more or less definitely proved that Beri-Beri is associated with a food deficiency. As stated by Manson, it may be just possible that the condition brought about by this deficiency merely predisposes to, or is necessary for, the operation of something else, perhaps a germ, which in the absence of this deficiency, would remain inoperative even if introduced.

The anti-Beri-Beric vitamin is largely contained in the sub-pericarpial layer which is practically entirely removed by the process of milling uncured rice, and Funk has shown that the substance is present in rice polishings in the proportion of 1 in 10,000. The same observer has proved that similar anti-neuritic bodies exist in other cereals and in a variety of food stuffs, *e.g.* heart muscle, egg yolk, yeast, lentils and barley.

Experiments show that the rice vitamin fraction can be split up into three substances, one with a formula of $C_{24} H_{19} O_9 N_5$, second with a formula, $C_{29} H_{23} O_9 N_5$, and thirdly what appears to be nicotinic acid. The first substance mixed with the nicotinic acid appears to be necessary for curing Polyneuritis artificially produced in pigeons by special diet of white or machine polished rice.

As far as is known at present, the disease appears to be due to disturbance of metabolism due chiefly to the prolonged use of polished rice as a staple article of diet or to a diet deficient in the necessary vitamins, combined possibly with unsuitable climatic conditions and surroundings, and stress.

The campaign in Mesopotamia was marked by an outbreak of this disease among the troops both British and Indian.

The symptoms exhibited corresponded with the various types known clinically.

Fulminating, dry and wet and mixed cases were all experienced. This is the first occasion on which such a large number of cases among British troops on active service has come under observation. Their diet consisted of fresh and tinned meat, wheat bread, rice, no fresh potatoes, vegetables scarce, jam in plenty and lime juice. The water was from the river, treated with alum and subsequently boiled.

At times they were without fresh meat for 2 or 3 weeks. Milk, butter and eggs were not available except at long intervals.

Many of the troops had only been a few months in India under conditions of climate, work and surroundings to which they were not accustomed and then they proceeded to a climate, where such conditions were accentuated and they worked under a certain stress both physical and mental.

Beri-beri has also occurred in Brazil among labourers who ate considerable quantities of tinned vegetables. In both of these cases it is possible that the high degree of heat employed in sterilising tinned food also destroyed the anti-beri-beri Vitamin.

PROPHYLAXIS OF BERI-BERI.

Diet is most important.

On a campaign or a long sea voyage, it is often difficult to avoid some deficiency in those articles of diet which are especially rich in anti-Beri-Beri vitamin.

Haricot beans, pea powder in the form of pea soup, and porridge are valuable and convenient.

Fresh vegetables are important but, of course, sometimes unprocurable. General sanitary measures and personal hygiene should be kept at as high a standard as possible.

Articles of diet for Beri-Beri cases, arranged in order as regards their vitamin value :—

1. Yeast.
2. Eggs (raw or lightly cooked).
3. Brain.
4. Liver.
5. Sweetbread.
6. Kidneys.
7. Heart muscle.
8. Peas.
9. Haricot beans.
10. Katjang idjæ beans.
11. Lentils.
12. Porridge.
13. Brown bread.
14. Milk (fresh, if possible).
15. Fish or meat.
16. Ordinary bread or biscuits.

The following suggestions have been made and would be extremely valuable, especially in institutions like Jails, Boarding Schools, etc. :—

1. Whole-meal bread should be used whether the grain be wheat or Jowar or Bajree.
2. Undermilled or cured rice should be used.
3. Fresh leguminous vegetables should be served once a week at least.

4. Fresh fruit should be issued twice a week.
5. Barley, a very valuable preventive of beri-beri should be freely used.
6. Potatoes and fresh meat should be frequently served preferably once a day.
7. The too exclusive use of canned foods must be avoided.

Rabies (Hydrophobia in Man).

Rabies is an acute disease of the central nervous system occurring in dogs and allied animals, and transmitted from animal to animal by means of bites.

The term Hydrophobia is applied to the disease as met with in man only, as the fear of water (hydrophobia) is not seen in the lower animals.

Etiology.—The actual agent has not yet been identified, but there is no doubt that the disease is caused by an organism which may be termed the *rabies virus* and which is present in the saliva of affected animals.

This virus is found in the brain, spinal cord, and large nerves; also in the salivary glands and in certain internal organs, *e.g.* the pancreas and supra-renal glands.

The saliva of human beings and herbivora contains practically no virus.

The virus gains entrance into the body through some broken surface of skin or abraded mucous membrane, *e.g.*, the bite of a rabid animal; the infected saliva coming into contact with a recent cut or abrasion.

From experiments made by Acton and Knowles, it has been determined that the saliva is never infectious earlier than 72 hours before definite symptoms appear. They are of opinion that "*if the biting animal remains alive and well for ten days after biting a human being, the saliva cannot have been infective and treatment in such cases is not necessary.*"

The milk of animals suffering from Rabies seldom contains any virus.

For all practical purposes, the saliva is the only infective material from which man and other animals contract Rabies. The virus passes from the brain into the salivary glands and thence into the saliva of an infected animal.

Dogs, jackals, horses, mules, cats, cows, and buffaloes are all susceptible.

By far the greatest number of cases of Rabies occurs in dogs and next in jackals.

Incubation period.—The incubation period is very variable. It varies from about 16 to 90 days. The variability of the period depends (1) upon the dose of the poison or virus inoculated and (2) the proximity of the bite to the brain. The above-named observers believe that "depth of the bites, bareness of skin, and multiplicity of bites are of greater importance than the actual situation of the bites."

A dog or other animal that has been bitten by a rabid animal should be segregated for at least 3 months and kept under close observation for another 3 months.

Rabies in the dog.—Two types are described :—

(*a*) Dumb or Paralytic Rabies.

(*b*) Furious Rabies.

The symptoms are extremely variable. Sometimes the dog is furious and later on dies in a paralysed state; at other times only paralysis is seen; more rarely the animal is only restless and off food and dies in convulsions in a few hours. The symptoms vary also with the kind of dog under observation. In pariah dogs and young puppies symptoms of furious rabies are common, and hence human beings are often bitten by such dogs.

Well cared-for dogs, on the other hand, rarely bite human beings; in fact, in earlier stages they often show an increased affection for their masters.

For descriptive purposes, the symptoms may be classified under two main headings :—(i) *Brain irritation* and (ii) *Paralysis*.

(*i*) Restlessness, as shown by the animal straying away from home or aimlessly wandering up and down the room, and every now and then hiding away in dark corners. In well-kept dogs this restlessness is often missed, as the dog continually comes up to his master to be petted.

Hallucinations.—The dog snaps at imaginary objects. In well-cared for dogs, the eating of filth may be looked upon as a characteristic symptom.

Fury.—This varies with the kind of dog. In well-kept dogs fury is, as a rule, only vented on inanimate objects by tearing up bedding or the ground or biting at the chain or post to which it is tied.

Such a dog almost invariably quietens down on the approach of its master. It may attack other animals, but rarely viciously bites human beings.

With pariah dogs the case is different, for they attack all and sundry who happen to cross their path.

Convulsions.—The most typical sign of brain irritation is the occurrence of convulsions, affecting the whole body.

As a rule, convulsions do not appear until paralysis has set in and is marked. In young animals convulsions appear early in the disease, and cause death within a few hours from the onset.

Besides the symptoms mentioned above, other early signs are—

(1) Fever and rapid pulse.

(2) Increased salivation may or may not be present.

(3) Wrinkling of the forehead and brow.

(4) Redness of the conjunctiva.

(*ii*) Paralysis generally follows the symptoms of brain irritation. It usually commences in the hind legs and is shown by the waddling gait of the dog.

This may be preceded or followed by paralysis of the throat and laryngeal muscles. The former is shown by difficulty in swallowing, and the latter by the alteration in note and pitch of the bark. Instead of the normal clear bark, which consists of a succession of sounds, equal in length and intensity, it is raucous, muffled and deeper in tone.

The first bark commences with open mouth, followed immediately by five or more barks which come from the back of the throat, and during each bark the jaws are not properly closed, as they are in the healthy bark.

The paralysis extends to the jaw muscles, and the lower jaw finally drops.

The animal gradually becomes entirely paralysed, so that it can neither sit, move nor feel. During this end stage of complete paralysis, convulsions supervene and hasten the end.

Once definite symptoms appear, life is rarely prolonged for more than 2 to 5 days.

At the Kasauli Institute, the following signs and symptoms are considered of importance :—

(1) The short duration of the disease, 2 to 5 days.

(2) The infallible termination of the disease in death.

(3) Hallucinations," bone in the throat," and paralysis of the hind limbs.

(4) Many persons bitten by the animal at the same time, and the attack being without provocation.

In animals there is never any difficulty in eating or drinking until the last stage of the disease, when paralysis of the throat muscles makes these acts impossible. The animal never exhibits a dread of water.

TREATMENT.—As soon as possible the wound should be well washed, dried and cauterised either by pure carbolic acid, permanganate of potash, pure nitric acid or silver nitrate.

Pasteurian treatment for the prevention of Hydrophobia.—The wound having been efficiently cauterised, the bitten person has next to decide whether he should have Pasteur's treatment. The Kasauli Institute authorities recommend the following procedure :—

" The first consideration is the state of the dog's health " We may classify cases under the following headings :—

(*a*) Dog is dead, and has been certified as being rabid by a medical or veterinary officer, or is suspected of Rabies.

(*b*) Dog is unknown.

(*c*) Dog is still alive and can be put under observation.

" (*a*) *Dog is dead, and is certainly rabid.*—In these circumstances, all persons bitten, and all persons licked on definite cuts or abrasions must proceed at once for treatment to a Pasteur Institute. Contact of saliva on granulating wounds is devoid of any danger.

" *Dog is suspected of Rabies.*—A popular idea appears to be prevalent that the brain should be sent to a laboratory and, if the result be positive, the patient should then proceed for treatment. At Kasauli we place little reliance upon the microscopical test. Therefore, when the dog is dead, and the symptoms are at all suspicious of Rabies, it is better to be on the safe side and to undergo treatment.

"(b) *Dog is unknown.*—These cases frequently occur amongst policemen, etc. They are patrolling up and down a bazaar and a dog suddenly rushes out and bites them in the dark and nothing more is seen or heard of the dog. Under these circumstances, *i.e.*, an unprovoked attack, it is better to assume that the dog was rabid and to send the patient up at once for treatment.

"(c) *Dog is still alive.*—Under no circumstances should the dog be destroyed for, by so doing, one of the most important signs of Rabies, *viz.*, the short duration of life, 2 to 3 days, is lost.

"If the animal shows no symptoms and remains alive and well for 10 days, the saliva cannot have been infective, and therefore, the bitten person need have no further fear, even should the dog develop Rabies at a later date. On the other hand, if the dog, whilst under observation during these 10 days, appears ill and if the person is bitten on the face or has been badly bitten elsewhere, *i.e.*, many deep bites on bare skin, it is better for him to proceed at once to a Pasteur Institute, in order to avoid any delay in commencing treatment.

"If the animal should die within these 10 days, it may be surmised that it is rabid and treatment therefore becomes necessary.

"Persons bitten or licked by rabid animals more than two months previously are, as a rule, not treated. Most cases have either developed Hydrophobia or have, in all likelihood, escaped infection on the expiry of two months from the date of the bite or lick. Therefore treatment is not advised in such cases.

"In any case of difficulty or doubt a detailed telegram should be sent to the Institute stating symptoms, the circumstances of the infection, etc., when an opinion can often be given. In cases where treatment is not necessary, this may save patients from the expense and trouble of a long journey."

ANTI-RABIC TREATMENT.

Preparation of anti-rabic Vaccine.—Rabbits are inoculated subdurally with Rabies fixed virus. On the 5th or 6th day the animal shows symptoms of Rabies and is killed when completely paralysed *i.e.*, on the 8th or 9th day. The brain and spinal cord are removed, weighed and pounded up in carbolised saline. The required strength is made up and bottled in ampoules.

Classification of cases.—For the purpose of treatment the cases of dog bite are classified as follows :—

Class I. Cases not bitten but in which the saliva of rabid or suspected animal has come into contact with fresh cuts or abrasions (licks).

Class II. Superficial but not extensive bites on the trunk and extremities (excluding the fingers).

Class III. (*a*) All superficial bites on fingers.

(*b*) Superficial extensive bites on all parts of the body except the head and neck.

(*c*) Deep but not extensive bites on all parts of the body except the head and neck.

Class IV.—(*a*) Deep extensive bites on all parts of the body.

(*b*) All bites and scratches on the head and neck.

Doses.—The doses prescribed for these classes are the following :—

Class I. 2 per cent. anti-rabic vaccine 5 c.c. daily for 7 days.

Class II. 2 per cent. anti-rabic vaccine 5 c.c. daily 14 days.

Class III. 5 per cent. anti-rabic vaccine 5 c.c. daily for 14 days.

Class IV. 5 per cent. anti-rabic vaccine 5 c.c. daily for 14 days.

During the treatment, patients are not in any way inconvenienced and not the slightest danger to health need be apprehended. The inoculations are unaccompanied by fever. A local reaction sometimes occurs about the 8th or 10th day of treatment, but it is never anything more than slight local redness and swelling which can be relieved easily by the local application of a hot water bottle or of hot fomentations.

THE DUTIES OF LOCAL AUTHORITIES AS REGARDS THIS DISEASE ARE :—

(1) Steps should be taken as may be practicable for informing the public as to the nature of the disease.

(2) All cases must be duly reported and dealt with so as to prevent the spread of the disease.

(3) All animals liable to take and communicate the disease may be muzzled, till the disease is stamped out.

(4) Arrangements should be made for sending to the Pasteur Institute any human being bitten by a rabid animal as promptly as possible. Government, Municipalities and other local bodies pay all expenses to poor people, according to the rules laid down on the subject by Government.

WORK OF DOG DESTRUCTION IN BOMBAY.

A dog-catching establishment is maintained in the city, the Government bearing half the expenses. The number of dogs caught and destroyed averages 9,000 a year. The capturing of dogs is effected by means of American Buck-skin gloves. There are eight units working in the city. Each unit consists of—

(1) One overseer.

(2) Two catchers.

(3) One driver with a specially constructed single bullock cart.

The method adopted in Bombay for the destruction of stray dogs is as under.

The Unit moves out after giving muster at the depot to which it belongs and searches the areas assigned to it for stray dogs. Public roads, streets and places are only visited. Dogs in private compounds or houses are not dealt with. The Police is referred to whenever complaints are received.

The Catchers wear American Buck-skin gloves which are of special make and intended for this kind of work. They are also provided with one pair of tongs three feet in length with a catch-head of $3'' \times 5''$.

On spotting a stray dog on a road or public place, one of the catchers moves unconcernedly until he gets ahead of the animal. By this time the 2nd catcher gets as close as he can in the rear of the animal. Then catcher No. 1 turns round and moves slowly towards the animal. The animal wondering to himself as to what the catcher No. 1 is about, stands gazing at the figure moving towards him, and while in this state of perplexity, he remains unconscious of the movement of No. 2 who has in the meantime taken advantage of the enforced stand of the animal by laying hold of one of the hind legs of the animal, lifting it off the ground and giving it a quick whirl round. No. 1 runs up and with his gloved hand catches the dog by the muzzle and both carry the captive to the cart. Sometimes as the Unit is moving along, dogs are picked up straight off from the ground, the

catcher laying hold of the canine by the neck taking good care to keep the lower jaw under pressure of the left hand.

The tongs are only brought in use in case of rabid dogs or when the dog to be captured is found to be too powerful and likely to be unmanageable for catching by means of gloves.

After a sufficient number of captures have been effected the Unit moves back to the depot for registering its catch and taking a slip from the clerk to the Officer in charge of the Lethal Chamber.

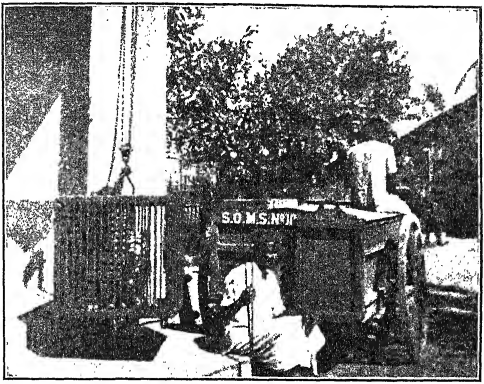
On arrival at the Lethal Chamber, the Officer in charge checks the slip with the number of dogs in the carts. The cart is then emptied out into the waiting barred enclosure.

At 4 p.m. the captives are ushered into an iron barred cradle worked in conjunction with the Lethal Chamber, into which it fits when lowered. This cradle has suspension chains fitted with overhead traction wheels and pulley arrangement, for raising and lowering; an iron girder overhangs the centre of the Lethal Chamber and it is to this girder that the cradle is attached and along which it slides.

The destruction or disposal of dogs thus cradled is secured through the medium of Co_2 gas, with which the Lethal Chamber is charged, after the cradle containing the dogs is lowered in it. The subjection of the animal to the gas for a couple of minutes completes the operation, life being rendered extinct.

The cradle is then raised out of the chamber and the carcasses removed and taken to the refuse Siding, from where along with other carcasses of animals, they are taken to Deonar, a place outside the limits of the city, for disposal.

The Lethal Chamber is located in a spacious room which is fitted with a dog detention or waiting barred enclosure.



Cart for catching Dogs and the Dog Cradle ready for being lowered in the Lethal Chamber.

Typhus Fever.

Synonyms.—Spotted Fever. Typhus Exanthematique. Prison Fever.

An acute specific fever, characterized by sudden onset, a macular petechial eruption, and severe toxæmia. The fever after a definite course generally ends by crisis.

The disease is rare in India. The incubation period is generally from 5—21 days, usually 12 days.

Symptoms.

The onset is generally rather sudden, being characterized by frontal headache, a feeling of chilliness, fatigue and malaise. There are pains in various parts of the body, of which pain in the chest giving rise to a

suspicion of Pneumonia is important; marked rise of temperature (from 101° to 104° F.), quick pulse, flushed face and suffused eyes, quickened respirations and a sensation of weakness. The nervous system is early affected, the patient being apathetic and drowsy, with a dull expression.

Leucocytosis is well marked.

The differential leucocyte count is of importance, the poly-morpho-nuclear increase is a characteristic feature, and may exceed 90 per cent. while the mono-nuclears and lympho-cytes may be reduced, and the eosinophiles are often entirely absent.

About the 4th to 6th day the typical rash appears. This is not easily discerned in coloured people.

About the 8th to 9th day a pseudo-crisis may be noticed and later the eruption fades and disappears.

The temperature falls by crisis on the 10th to 12th day, or by lysis during the two days, to normal, and convalescence begins.

Recovery is usually quick and relapses extremely rare. Ten days or a fortnight after the fall of temperature, the patient will probably be convalescent, free from infection and fit to be discharged. Death may take place during the first week or about the 10th day from toxæmia.

The important diagnostic signs are the leucocytosis, the rash, and the extreme nervous prostration.

Compared with Relapsing Fever, Typhus shows a less abrupt onset and marked mental symptoms (stupor) and dark macular eruptions about the trunk, on the 4th to 6th day.

Typhus Fever probably more nearly resembles Plague at its onset than any other disease. There is marked clouding of the consciousness and intense prostration as with Plague and the eruption does not appear before about the 4th day.

It is a disease associated with poverty and filth. It occurs in temperate climates, mostly in winter and spring. It is uncommon in warm climates.

The disease is now believed to be transmitted by the agency of body lice. These live in clothing and bedding and are never far removed from their hosts. They are delicate creatures and require nourishment at frequent intervals.

For this reason the problem of extermination of lice resolves itself into the question of the efficient cleansing of the person and clothing.

There is also evidence that the virus of Typhus Fever can be transmitted by lice through the eggs to their offspring, and for this reason all measures directed against the louse on grounds of infection should be extended also to the eggs.

Lice are most infective 5-7 days after feeding on a patient which indicates that the virus probably undergoes some development in the body of the louse. The virus is filterable. Guinea pigs and apes can be infected by injection of blood drawn during the febrile stages.

Minute rod-shaped bodies (Rickettsia prowazeki) with polar staining have been found in typhus blood and in the stomach and salivary glands of infected lice. They are probably protozoa and may be the real cause of the disease.

PROPHYLAXIS.

Destroy the lice and disinfect the clothing and bedding. A temperature of 160° F. to 175° F. is sufficient to kill lice and their ova.

Whenever a case of Typhus is discovered in a house, not only the clothes and bedding of the patient should be disinfected in a sterilizer but also those of all other members of the family. In addition to the patient, any persons occupying the adjoining rooms should be given a good bath and all their ecto-parasites carefully removed by washing, followed by an application of camphorated ointment. Any room occupied by the patient and also those adjoining should be disinfected with sulphur fumigation.

Some believe that infants seem to possess a natural immunity against the infection, which gradually diminishes as they grow older.

There is little danger of direct infection from a Typhus patient when he is kept under hygienic conditions; any contact with unwashed patients or their clothes or bedding

is very dangerous, as shown by the number of cases occurring among washer-women, porters, hospital attendants, &c.

LIFE HISTORY OF THE HUMAN LOUSE.

The human louse belongs to the Pediculidæ or Lice family (Anoptera), of which three species infect man in India, *viz.*, (*a*) the Head Louse, (*b*) the Body Louse, and (*c*) the Pubic or Crab Louse.

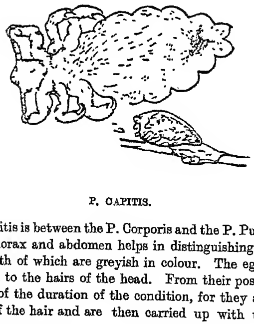
(*a*) The Head Louse or P. Capitis.

As its name indicates, it is found on the head.

It is an insect of a greyish colour, with a flat, slightly transparent body. There are black spots on the spiracles.

The head, which is oval, is furnished with two thread-like antennæ composed of five joints, which are constantly in motion while the creature is walking. Its eyes are black, round and of simple structure. In front of the head is a short, conical fleshy nipple. This contains a sucker, which the insect can put out when it likes, and which, when extended, represents a tubular body, terminating in 6 little pointed hooks, bent back and serving to retain the instrument in the skin.

The limbs are very thick, terminating in a strong nail, which folds back on an indented projection, thus forming a pincer, by means of which it fastens itself to a hair.



P. CAPITIS.

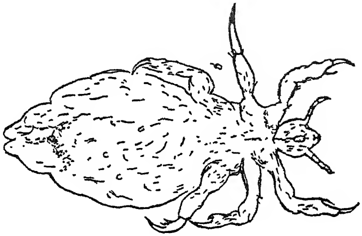
The P. Capitis is between the P. Corporis and the P. Pubis in size. The shape of the thorax and abdomen helps in distinguishing P. Capitis from P. Corporis, both of which are greyish in colour. The eggs or "nits" of P. Capitis stick to the hairs of the head. From their position on the hair one can judge of the duration of the condition, for they are fixed at first near the root of the hair and are then carried up with the latter in its growth.

The higher up the nits are, therefore, the longer have the pediculi been present.

The young are hatched in about 5 or 6 days; and in 18 days are able to produce their kind.

(*b*) The Body Louse or P. Corporis.

It is greyish in colour. It is the longest and narrowest of the three. It varies somewhat in colour with that of its host. It is larger than the head louse and less bristly.

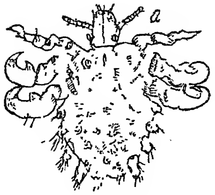


P. CORPORIS.

It infects beggars, people of unclean habits and those who through force of circumstances are unable to have frequent changes of garment and baths, *e.g.*, soldiers on active service. It should be looked for in the seams of the clothes, especially where the latter come in close contact with the skin, *e.g.*, over the shoulders.

(*c*) The Crab Louse or P. Pubis.

It is found on the parts of the body covered with short hairs, usually in the vicinity of the pubis and axilla. It is readily communicable from person to person.



P. PUBIS.

It is the shortest and broadest of the three, and is yellowish-brown in colour.

In the case of the body louse, the eggs take one to five weeks or longer to incubate according to temperature. The young louse, when just hatched, sucks blood at the earliest opportunity. It is however not sexually mature: after $3\frac{1}{2}$ months the growth is complete and the insect is sexually mature. The females lay 100—200 eggs. They are voracious feeders and do not stand starvation for more than 2 days. They are very sensitive to heat and drying and succumb at temperatures above 25° C. unless the air be kept nearly saturated with moisture. They live in clothing and bedding and feed several times in the 24 hours if opportunity be given.

The body louse obtains its nourishment entirely by sucking blood. It is provided with penetrating instruments, the apposition of which forms a canal through which the blood is pumped into the stomach by a pharyngeal pump similar to that of the flea.

The infection of Typhus is supposed to circulate in the blood during and for some time after the febrile period and it is taken up by lice when they feed upon a patient. The infectivity of lice endures for about seven days.

DESTRUCTION AND AVOIDANCE OF LICE.

For the head louse, when the condition is very bad, the hair should be cut short or shaved. Repeated saturation of the hair with turpentine or with paraffin oil is usually efficacious.

In the case of the body louse, the clothing should be thoroughly disinfected in a special apparatus. To allay the itching, a warm bath containing 4 to 5 ounces of bicarbonate of soda is useful.

For the P. Pubis, Ammoniated Mercury or ordinary Mercurial ointment may be used, and the affected parts should be washed 2 to 3 times daily with soft soap and water.

Prof. Maxwell Lefroy recommends the following measures for the avoidance and extermination of lice :—(1) When exposed to lice, protection can be obtained by smearing the skin with a small amount of crude oil emulsion, rubbing it in the hair, applying it in the stockings, inside boots or puttees and along the seams of clothing. It can be used as a soap when bathing and a little rubbed on the skin afterwards. The form of crude oil emulsion has been adopted by the Army Medical Corps under the name of *Vermijelli* to be used with N. C. I. Powder.

CRUDE OIL EMULSION.

Crude mineral oil	56 grms.
Soft soap..	30 ,,
Water	About 6 c. c.

Major Lelean's formula for N. C. I. powder.

Powdered napthaline	96 per cent.
Creosote	2 ,,
Iodoform..	2 ,,

2. If actually infected with vermin, rub Vermijelli on the hairy parts of the body and on the seams of under-clothing and trousers ; dust N. C. I. powder on the body and on the inside of under-clothing.

3. Vermin, *i.e.*, lice, require single upstanding hairs or fibres on which to lay eggs, and wool offers the most suitable medium owing to the immense number of isolated fibres that stick out on the surface. Silk clothing is less suitable because the fibre is continuous and ends do not stick up on the surface.

Wool can be made vermin-proof by Vermijelli.

The emulsion should be used in the hospital laundry as soap or in combination with other soaps.

Crude oil emulsion, if prepared from suitable oil, is not inflammable ; it is non-poisonous and it may be retained upon the skin indefinitely.

Moore's Powder: Creosote, 1 c.c., Sulphur 0.5 gm.; and talc 20 gms. will be found much less irritating and far more effective than the N. C. I. powder mentioned above.

Those attending on cases should wear gowns closely fitting at neck and wrists and rubber gloves. Better still would be "unionalls" with stocking, extremeties to go over the shoes.

Malta Fever or Mediterranean Fever.

Malta Fever or Mediterranean Fever is a specific infectious fever of extended duration and frequent relapses, characterised by copious diaphoresis, and frequently accompanied by articular rheumatism and orchitis. Incubation period varies from 5 to 15 days.

A special bacterium, Brucella *melitensis*, is found in the spleen and lymphatic glands of the patients. It is excreted in the urine, and it occurs in great abundance in the milk and urine of apparently healthy goats in Malta (10 per cent.) and cows, and in the urine of apparently healthy man. The B. melitensis is closely related to Brucella abortus, the cause of contagious abortion in cattle. B. abortus also causes Malta fever in human beings.

In Malta and other places, where the disease is endemic, this fever assumes an epidemic character.

Mode of infection.—It is not usually directly communicable from the sick to the healthy. The germ is readily conveyed by inoculation; the prick of a contaminated needle will suffice. Goat's milk is the most important medium of infection. In 10 per cent. of the milk of Maltese goats, the micrococcus is present.

Prophylaxis.—The following measures suggest themselves:—

(1) Isolation or destruction of infected goats.

(2) The avoidance of goat's milk.

(3) Thorough boiling of goat's milk before use. This is the most economical and the most practicable protective measure. By its observance alone in the absence of all other measures, the disease was stamped out from among the naval and military forces of Malta.

Vaccines have been tried with apparent success as a prophylactic measure.

Dengue.

A specific febrile disease, peculiar to warm climates, occurring usually as a rapidly spreading epidemic and, in typical cases, characterised by a suddenly developed primary fever of about 3 days' duration, succeeded by a period of apyrexia—actual or relative—and this again by a milder secondary fever accompanied by a rubeoloid eruption. Throughout the febrile stages, and often subsequently, severe rheumatic-like pains are a prominent symptom. The disease in its active form lasts about a week and is attended with little if any, mortality.

Back-ache and pains about the muscular attachments at the joints and especially a marked post-orbital soreness are important features.

Etiology.—Like Yellow Fever, the disease is due to a filterable virus present in the patient's blood from the 2nd to the 5th day. It is transmitted by the mosquito Aedes Egypti. (Stegomyia fasciata).

It can be communicated by inoculation of infected blood.

High atmospheric temperature appears to be one of the conditions the disease demands. Like Yellow Fever it would appear to prefer the coast line and the deltas and valleys of great rivers, but there are many exceptions to this rule. Further, elevated places usually enjoy a relative immunity.

Incubation.—The period is somewhat variable.

1 to 5 days usually, however, probably 1 to 3 days.

The disease manifests itself with striking suddenness.

Convalescence is apt to be protracted and characterised by malaise and nervous depression.

Prevention.—This rests on the prompt isolation of the patient and the prevention of the mosquito from biting a patient. The virus is stated to be in the blood for a period of 4 or 5 days.

Vigorous anti-mosquito measures must be carried out in the area.

Trypanosomiasis of Man or Sleeping Sickness.

Sleeping Sickness is caused by the entrance into the blood and cerebro-spinal fluid of special species of Trypanosome. Monkeys, rats, dogs, cattle, horses and camels are susceptible to this form of the disease; but up to the present, guineapigs, donkeys, goats and sheep have not been found to be so.

The Trypanosome gambiense is transmitted from the sick to the healthy by one species of the tsetse fly, the Glossina palpalis. The T. Rhodesiense is transmitted by another species the Glossina morsitans. The distribution of Sleeping Sickness and of Glossinæ correspond.

The Glossina palpalis is generally found near water and requires a cool, shady, not too dense, undergrowth to thrive in. G. Morsitans prevalent in Rhodesia breeds in any locality. The tsetse fly is not unlike the ordinary house fly, but on examination it will be found to differ very markedly. It has in front a long straight proboscis with which it sucks blood.

Fly belts.—The fly occurs in well-marked tracts, the so-called "fly belts of Africa."

It lives exclusively on blood and feeds on any animal.

Koch considers that G. Palpalis is especially partial to crocodiles.

Incubation period.—2 to 3 weeks; may extend to some years.

Symptoms.—The bite of an infected Glossina is followed by local irritation and fever recurring at irregular intervals. The cervical glands are enlarged and tender ; skin affections and local œdemas are present ; the spleen and liver are enlarged.

The condition known as Sleeping Sickness is the terminal stage of Trypanosome infection. The average duration of this stage is from 4 to 8 months.

METHODS OF PREVENTION.

As in the case of Malaria, there are two broad principles to be recollected in conducting operations for the prevention of diseases disseminated by the tsetse fly :—

(I) Operations directed against the fly.

(II) Operations directed against the parasite which the fly transmits.

In regard to the prevention of the spread of Sleeping Sickness, the above principles may be applied practically in the following directions :—

I—Operations directed against the fly.

Destruction of the pupæ of the fly.—(*a*) By the clearing of undergrowth, particularly near towns, encampments, fords, etc., in fact, wherever human beings are brought together in numbers. The clearing is best effected by burning. The heat generated by the fire, and the exposure of the air to the full effects of the sun's rays by removing the shady undergrowth render the district unsuitable for the fly by raising the temperature above the point favourable to the development of the nymphæ. So in time the fly will die out of these "cleared areas." The fly does not exist apparently in hot, dry countries, *e.g.*, Egypt and India, probably owing to the fact that the nymphæ cannot develop under conditions found in these countries.

(*b*) *Destruction of the foodstuff of the fly.*—The fly, as has been seen, lives almost exclusively on blood; hence if deprived of the source of food supply, a diminution in numbers in the first instance and, ultimately, complete eradication might be expected. If the views of Koch be correct, the problem is further simplified; because he is of opinion that the crocodile is the chief source of supply of food for the G. Palpalis, and he has accordingly recommended the wholesale destruction of these animals.

II.—Operations directed against the parasite which the fly transmits.

It is obvious that if we can devise means for preventing the fly from becoming infected by the Trypanosome it will cease to be a disseminator of Sleeping Sickness. In the case of animals infected by trypanosomes, the problem is comparatively simple and consists in the slaughter of such animals as are found harbouring the parasite, and in this way the disease is stamped out gradually. In the case of man, means have to be discovered by which it will be possible to completely destroy all the trypanosomes without damaging seriously the host. This problem has not yet been solved but it is engaging the serious attention of a number of investigators.

DESTRUCTION OF TRYPANOSOMES IN THE VERTEBRATE HOST BY DRUGS.

Treatment.—Persistent and energetic use of arsenic or antimony or both. Intramuscular injections of preparations like atoxyl, soamin, arseno-phenylglycin, arsacetin, salvarsan, etc., have been tried. Atoxyl in large doses is apt to give rise to optic neuritis and consequent atrophy and blindness.

Antimony in the form of sodium tartrate hypodermically has been shown to cause disappearance of T. lewisi in infected rats.

Germanin, 1 grm. in 10 c.c. of water, given intra-muscularly once weekly, up to 10 grms. has been found useful especially in the early stages. In later stages Tryparsamide by the intra-muscular or intravenous route is indicated. The initial dose is 1 grm. in 10 c.c. of water followed by 2 grm. thrice weekly up to 24 grm.

PREVENTIVE MEASURES.

I. Isolation camps.—These camps are situated in selected "fly-free areas," and receive the more advanced cases of Sleeping Sickness from the "fly areas." Every case of Trypanosomiasis, which is removed from the fly area, removes one source of infection for the fly. In these camps the patients are maintained and treated with drugs which have proved efficacious.

II. Detection of all harbourers of the Trypanosome and prevention of their movement into "clean fly-areas."—As will be readily understood, this is one of the most important methods of checking the spread of Sleeping Sickness; but, in order to put it into practice, it is absolutely essential that we should have a practical and certain means of detecting the harbourer of the parasite, even in the initial stages of the malady. Fortunately, the exact recognition of early cases of Sleeping Sickness has now been rendered easy and certain by the method of gland puncture. The juice of the enlarged glands of cases of Sleeping Sickness, especially the posterior cervical, shows many actively motile trypanosomes. Some of the juice can be obtained readily by puncturing a superficial gland in the posterior triangle of the neck with a hypodermic needle. The fluid is examined under a low power, 150 to 200 diameters, when the actively motile trypanosomes can be readily detected. In practice, the posterior cervical glands should be palpated and, if found to be enlarged, the traveller should be further examined by gland puncture to determine the presence or absence of trypanosomes in the gland juice. If the trypanosomes

are found to be present, the person should not be allowed to enter a tsetse fly-belt.

A convalescent from the disease, migrating to another country, should be periodically examined and kept in a fly-proof ward until he is pronounced free from infection.

THE TSETSE FLY.

The Glossinæ have very thick proboscis, and large wings having characteristic venation. The most striking peculiarity in the wing is the course of the fourth longitudinal vein, which bends abruptly upwards about the middle. The Glossinæ are never found in mountains; they are seldom seen above 3,000 ft.; they are rarely found in close cultivation. Their habitat is always in the neighbourhood of open water along the banks of rivers. They are most numerous along the water's edge. The essential conditions of a tsetse station are—the presence of open water, a wooded district and a loose soil.

Reproduction.—The Glossinæ do not lay eggs, but the eggs hatch and the larvæ feed, develop and moult within the body of the parent, so that when extruded they have practically reached the pupa stage.

Habits.—Tsetse flies are voracious blood-suckers. They bite almost exclusively during the day. Both males and females are blood-suckers.

Trypanosome.

In 1902 Castellani in Uganda discovered trypanosomes in the cerebro-spinal fluid, as well as in the blood of cases of Sleeping Sickness.

The trypanosome after entering the intestinal canal of the tsetse fly undergoes developmental changes requiring a considerable space of time for their completion.

These enable it subsequently to effect a lodgement in the human or other vertebrate host. The Tsetse fly is no mere mechanical transmitter of the trypanosome but is

a true intermediate host. From twenty days onwards to the forty-seventh day the flies convey infection (Kleine and Bruce). Bruce and his co-workers have found in Nayasland 1.35 per cent. of all wild tsetse flies infected with one or other of the disease-producing trypanosomes.

REGULATIONS ISSUED BY THE GOVERNMENT OF BOMBAY.

If a case of Sleeping Sickness occurs on any vessel after she has entered dock or has been moored at a wharf, the master shall forthwith cause information thereof to be given to the Dock Master or Superintendent of the wharf, who shall communicate the information to the Health Officer of the Port (through the Port Officer) and to the Superintendent of Police, and shall be responsible that the sick person is isolated as far as possible, and that free communication with the wharf is stopped until the Health Officer has inspected the vessel.

The Health Officer shall remove to a place appointed for the purpose in a building, permanently and effectually protected from access to biting flies by means of fine wire gauze netting, every person found on board suffering from or suspected to be suffering from Sleeping Sickness, and every such person shall be detained for observation and treatment in the said hospital or place, or any other hospital or place to which the removal of such persons may be authorized by Government, and shall be isolated in such a manner as will prevent as far as possible the communication of the disease to other persons by the agency of biting flies, and shall continue to be so detained and isolated until a medical officer, authorized in this behalf by Government, certifies that he is not suffering from Sleeping Sickness or that having suffered from the disease he has been cured.

The Health Officer shall inform the Municipal Health Officer in every case in which a person suffering or suspected to be suffering from Sleeping Sickness is removed under his orders to a hospital, or other place within Municipal

limits and, in cases in which the disease has not been definitely diagnosed at the time of removal, shall also report to the Municipal Health Officer whether the diagnosis is confirmed or not.

All persons removed to hospital or kept under observation at any place shall obey and conform to the rules, regulations and orders for the time being in force at such hospital or place.

Relapsing Fevers.

Relapsing Fevers are a group of specific fevers caused by a spirochæte (spirillum) present in the blood and characterised by febrile attacks varying in duration.

The spirochætes are conveyed by the bite of an insect. There are various species of the parasite more or less peculiar to local areas and conveyed by appropriate biting agents.

The disease occurs all over the world chiefly amongst the poor and uncleanly; bad food, defective sanitation, famine and overcrowding are predisposing causes.

Relapsing fever, formerly confused with Typhus and Typhoid Fever, is quite distinct from either. It is distinguished from Typhus by the occurrence of the relapse, and from Typhoid Fever by the absence of intestinal lesions. In this disease, as in others in this group, the period of incubation varies much, the range being from less than a day to three or four weeks, generally 5 to 7 days. It may be wholly latent for about a fortnight. Then there is probably a little malaise and nausea, followed by rigors, headache and pain in the back and limbs. There is also fever, which may run rather high, hurried breathing, cough, a flushed face, and yellow colouration of the skin due to jaundice. There is generally no rash, but, not uncommonly, rose-coloured spots appear on the chest, abdomen and limbs. This rash may come out on the third day of the fever, or not till the fifth, and disappears in a day or two. In some epidemics the appearance of a rose rash has been the rule. After the onset it is probably five or

six days before the disease will be recognised. The persistent yellow colouration of the skin and the rash if present will help the practitioner to a correct diagnosis which may very readily be confirmed by an examination of the blood if this has not been done already. The dullness over the spleen is always increased, and usually the dullness over the liver is also increased. There is also often distressing bilious vomiting and much thirst. After these symptoms have continued from five to nine days, there is a sudden crisis (which may be marked by diarrhœa, profuse perspiration, a rigor, &c.), and immediately the patient feels well. The crisis and the accompanying fall in the patient's temperature are almost always at night. The relapse generally occurs on the fourteenth day after the fever originally commenced; thus the intermission is of varying duration. The relapse is ushered in by rigors and lasts from three to four days, the symptoms being those of the primary fever and as severe. The second crisis is also abrupt, and followed by convalescence. Sometimes there is a second relapse, and even a third and fourth, the symptoms in these being less severe. During the intermission and after the relapse the temperature is sub-normal.

Although one of the names given to this disease is "Famine Fever," epidemics have occurred when work was abundant and there was no scarcity of food. Still it is eminently a disease of the very poor and commonly associated with destitution. As a rule, it is not a very fatal disease.

The Relapsing Fever of Europe and India is conveyed by the body louse; that of Africa by ticks (*Ornithodoros moubata*).

The various insects and other transmitters act merely in a more or less mechanical way. The spirochæte is abstracted with the blood when the insect-transmitter feeds; it multiplies in the gut and is afterwards passed out with the fæces and deposited on the skin of any human or other warm blooded victim on which the infected insect may subsequently feed.

The irritation caused by the bite of the insect provokes scratching and consequent inoculation of the deposited spirochætes.

In the case of *Ornithodoros moubata*, the hereditarily infected nymph can communicate the disease.

PREVENTION.

Prevention is easy for those who are careful about cleanliness of bed, bedding and clothing and protect themselves by avoiding infected areas.

Disinfection of bedding, clothes and beds, sleeping cots and infected dwellings should be carried out.

Filariasis and Elephantiasis.

Filariasis is infection of man, mammals, birds, etc., by various species of the genus Filaria.

Filariæ are long slender worms of almost uniform breadth. They have an incurved or spiral tail.

Of human filariæ man is the definitive host, and certain species of mosquito (Culicidæ) the *intermediary* host.

Filaria bancrofti.—It is found widely distributed in every tropical and sub-tropical country. The sexes are usually found in association up to 6 or 7 in number, all coiled up together and lying in the lymphatics of the trunk or extremities.

The young filariæ are ejected into the lymph surrounding the parent and are carried to the blood stream through the lymphatics and the thoracic duct; in the blood stream they exhibit a curious periodicity. At about 8 or 9 p.m. these small embryos (micro-filariæ nocturna) begin to appear in the peripheral blood increasing in numbers up to midnight and gradually decreasing thereafter until 6 or 7 in the morning. During the day they retire to the lungs and the larger blood vessels; thus they are found in the blood only at night time. Many species of mosquitoes have been found to act as hosts

under artificial conditions, but the natural carriers of filariæ belong to the species, Culex fatigans.

About an hour after the mosquito has gorged the infected blood, the blood becomes viscid. The parasites then bore through the wall of the mosquito's stomach and reach the muscles in 12 to 18 hours where they undergo further development. They then work their way through the muscular tissues till they reach the neighbourhood of the mosquito's salivary glands and pass into the neck, when one or more can readily enter the substance of the labium. When this mosquito next feeds on man, the filariæ gain a fresh human host, and ultimately find their way to the lymphatic trunks where the union of the sexes may occur, and the swarm of embryos is eventually poured into circulation thus completing the endogenous and exogenous cycles.

The presence of parent filaria in the lymphatics leads to :—

1. Lymphangitis.
2. Varicose glands.
3. Lymphatic varices.
4. Chyluria.
5. Elephantiasis.
6. Chylous Ascites and Chylous Diarrhœa.

Elephantiasis is by far the most frequent manifestation of filarial invasion and exceedingly common in some of the endemic districts.

The lower extremities are most commonly affected. The scrotum, arms and mammæ are more rarely attacked.

PROPHYLAXIS OF FILARIAL DISEASE.

1. *Anti-Mosquito measures.*—Unprotected wells, tanks, or stagnant pools should not be permitted in the neighbourhood of dwelling-houses. All the vessels used for storing water should be emptied at least once a week.

2. *Isolation of the infected.*—The person suffering from Filariasis should be regarded as dangerous to the community and compelled to sleep under a mosquito net.

3. The use of mosquito-nets by all living in the endemic area.

Cerebro-Spinal Fever.

Epidemic Cerebro-Spinal Fever is an acute infectious disease caused by the Diplococcus intracellularis of Weichselbaum. It is characterised by an initial naso-pharyngeal catarrh which may not progress further, but if it does, a generalised septicæmia results, followed by localisation in various parts of the body with consequent inflammation of these parts; the commonest sites being the meninges, brain, and spinal cord, giving rise to Meningitis, with varying degrees of Encephalo-myelitis. The other parts of the body most affected are the lungs, joints, pericardium and glands, whilst ulcerative endocarditis may also occur.

ETIOLOGY.

Age.—The disease is one of childhood and young adult life; and although the incidence tends to decrease slightly with age, no age is exempt.

Sex.—The male cases out-number the female.

Occupation.—The disease has always been recognised as being more or less peculiar to military camps and barracks.

Season.—The disease is more common during the colder months.

Previous health has apparently no bearing whatever on the incidence of the disease; many sufferers have been in perfectly sound health prior to the attack.

Mode of dissemination.—Overcrowding and fatigue increase the liability. It is now considered to be a definitely contagious disease.

The diplococcus can be isolated from the throat (naso-pharynx) of Cases of Meningitis, especially if examined early in the disease. The majority harbour the germ in their throat during the first week of the disease, and thereafter the germ is progressively more difficult to demonstrate. But even fully admitting the contagiousness of the disease, the comparatively small number of cases where a history of contact with a previous case exists, the relative rarity of multiple infection in the same house, and the irregular geographical isolation of certain cases during an epidemic, all combine to necessitate another theory, *viz.*, the carrier theory. This is now the accepted view.

From numerous observations made, it seems highly probable that the chief mode of transmission of the disease is during sneezing and coughing by droplet infection of the air by mouth spray.

Incubation period.—Not definitely known as yet. It is probably between 1-5 days.

Route of invasion of the Meningococcus.

The site of primary incidence is the naso-pharynx. From there the organisms may reach the pia-arachnoid by two paths :—

(1) *The transnasal route.*—By direct spread through lymphatics to the pia-arachnoid over the nasal sinuses.

(2) *Via the blood stream.*—Producing a primary meningococcal septicæmia with secondary localisation on the meninges.

Prophylaxis.

Isolation and segregation of contacts and disinfection of the nasal passages.

The precautionary measures adopted for Influenza may be enforced in this disease also.

For *Bombay Presidency* (excluding the City of Bombay) the following temporary regulations have been notified by Government, No. 570 (General Department) of 6th September 1921 :—

Cerebro-Spinal Fever Regulations.

(1) Appointment of special officer to carry out all measures necessary to prevent the spread of this disease.

(2) Notification of outbreak.

(3) Intimation of cases.

(4) *Segregation and disinfection :—*

(*a*) Isolating the patient;

(*b*) Disinfecting clothes, vehicles or other property exposed to infection.

(5) Disinfection of buildings.

(6) *Requisition of buildings.*—The District Magistrate may take possession of and occupy any vacant ground or building for the purpose of a camp, or hospital or dispensary.

(7) Destitute patients may be removed to the nearest hospital.

(8) *Public meetings.*—If it appears to the District Magistrate that any public meeting, theatrical or cinema performance or any gathering of persons in any hall, theatre or public building is likely to spread the disease, he may after giving due notice to the conveners or management of such building, gathering or performance prohibit the holding of the same. He may also close schools.

(9) Spitting in public may be prohibited.

(10) Public conveyances, waiting rooms, etc., include tramway and railway rolling stock and premises such as waiting rooms, offices, etc., used in connection therewith.

(11) *Infected travellers.*—The person in charge of any conveyance that has been used to carry a case of Cerebro-spinal Fever shall be responsible for—

(*a*) Removing the person so infected;

(*b*) Arranging for his accommodation and treatment at the nearest suitable place;

(*c*) Notifying the facts to the relatives of the patient and the local civil authority;

(*d*) Properly disinfecting the conveyance used by the patient.

(12) Examination of travellers.

(13) *Overcrowding of railway carriages.*—Overcrowding should be avoided and sufficient windows should be kept open to ensure proper ventilation.

(14) Co-operation of the Police.

(15) *Compliance with regulations.*—Every person to whom any order or requisition is directed under these regulations shall duly comply with the same.

(16) *Penalty.*—Whoever shall disobey shall be liable to be prosecuted under Section 188, Indian Penal Code.

Leprosy.

Definition.—Leprosy is a chronic infective granulomatous disease produced by a specific bacterium, and characterised by lesions of the skin, nerves and viscera eventuating in local anæsthesia, ulceration and a great variety of trophic lesions. After a long course it is almost always fatal. It is a disease of tropical and sub-tropical countries.

In India, in 1931, there were said to be 147,911 lepers in a population of 352,986,876—a ratio of about 4.2 per 10,000.

Leprosy is found in all climates and on all kinds of geological strata. Social conditions are an important factor in determining distribution : its endemic prevalence appearing to be bound up in some way with uncleanly habits, squalor and poverty.

Bacillus lepræ have been found in the nasal mucus of lepers. The initial lesion of the disease is a specific ulceration of the septum of the nose. The bacillus is also found in all leprous deposits and in the specific lesions of the liver, spleen, testes and lymphatic glands.

PREVENTION.

With few exceptions, the best authorities believe that Leprosy is propagated by prolonged contact. A sure and the most effectual way of suppressing the disease is thorough isolation of existing lepers. Where possible, lepers should be segregated in isolated asylums which should be so conducted as to prove attractive. Lepers ought not to be allowed to beg in the streets, to keep shops, or to handle food and clothes intended for sale, to wander about the country as pedlars or

mendicants, to hire themselves out as servants or prostitutes, or to frequent fairs and public places. All lepers with ulcers should be more scrupulously isolated, their discharges, clothes and dressings being systematically destroyed or disinfected.

Among other measures may be mentioned :—

Scrupulous and systematic attention to personal and domestic hygiene and cleanliness ; frequent bathing and free use of soap ; frequent change of underclothings : good food, fresh air, light work and the avoidance of fatigue and of exposure to bad weather.

The Bombay Leper Act No. III of 1898 authorises the Police to segregate pauper lepers in the Matunga Leper Asylum of Bombay after they are examined and certified by the Police Surgeon. This *Act* was based on the findings of a Commission (that sat in the year 1891) who were of opinion that Leprosy was not a contagious disease. Since then rapid strides have been made in the knowledge of this disease, and the conclusion arrived at by the International Conference, that met in Bergen in the year 1909, are vastly different from those made by the Commission of 1891.

Some of the conclusions arrived at as the result of the deliberations at the Bergen Conference are as follows :—

1. Leprosy is a disease which is contagious from person to person, whatever may be the method by which this contagion is effected. Every country, in whatever latitude it is situated, is within the range of possible infection by Leprosy, and may, therefore usefully undertake measures to protect itself.
2. In view of the success obtained in Germany, Ireland, Norway and Sweden, it is desirable that other countries with Leprosy should proceed to isolate their lepers.
3. It is desirable that lepers should not be permitted to follow certain occupations which are particularly dangerous in respect to the contagion of Leprosy.

In every country and in all cases the strict isolation of leprous beggars and vagrants is necessary.

4. It is desirable that the healthy children of lepers should be separated from their leprous parents as soon as possible and that these children should remain under observation.
5. An examination should be made from time to time of those who have lived with lepers by a competent physician.

The British and Colonial delegates to the Conference had a meeting at which they drew up additional resolutions, which in their judgment embody, when read in conjunction with official resolutions of the Bergen Conference, the line of administrative policy which it is desirable to adopt for the prevention of Leprosy throughout the British Empire, so far as local circumstances permit. These resolutions are as follows:—

1. Leprosy is spread by direct and indirect contagion from persons suffering from the disease. The possibility that indirect contagion may be effected by fleas, bugs, lice, itch, parasite, etc., has to be borne in mind. Leprosy is most prevalent under conditions of personal and domestic uncleanliness and over-crowding, especially when there is close and protracted association between the leprous and non-leprous.
2. Leprosy is not due to the eating of any particular food, such as fish.
3. There is no evidence that Leprosy is hereditary; the occurrence of several cases in a single family is due to contagion.
4. In Leprosy an interval of years may elapse between infection and the first recognized appearance of disease. It is a disease of long duration, though some of its symptoms may be quiescent for a considerable period and then recur.

5. The danger of infection from leprous persons is greater when there is discharge from mucous membranes or from ulcerated surfaces.
6. Compulsory notification of every case of Leprosy should be enforced.
7. The most important administrative measure is to separate the leprous from the non-leprous by segregation in settlements or asylums.
8. In settlements home life may be permitted under regulations by the responsible authorities.
9. The preceding recommendations, if carried out, will provide the most efficient means of mitigating the leper's suffering and of assisting in his recovery, and at the same time will produce a reduction and ultimate extinction of the disease.

The Bergen Conference was attended by renowned specialists from every part of the civilized world and the unanimous conclusions arrived at by them are sufficiently indicative of the lines on which the present Act should be amended.

The following measures have been suggested in the case of lepers not actually in Asylums:—

(1) Utmost cleanliness should be enforced.

(2) A leper should have his own special set of utensils and other articles of common use and they should on no account be allowed to be mixed up with other articles in the house.

(3) A leper should have special sets of clothing which no one else should be allowed to use. All articles belonging to a leper and used by him should be thoroughly disinfected before being sent out to a laundry.

(4) A leper should be provided a separate room in the house and should as far as practicable avoid using public conveyances and attending social functions.

Attendants on lepers whether at home or in Asylums may usefully observe the following rules :—

(*i*) Rubber gloves should be worn wherever possible.

(*ii*) The hands, etc., should be thoroughly washed with soap and water after contact with lepers or articles used by them.

(*iii*) General health should be maintained at as high a level as possible by good food, fresh air, regular exercise and the observance of general sanitary measures.

Treatment :—

In addition to removal to Asylums or segregation at home and general hygienic measures, the following drugs have been tried with varying results—Chaulmoogra oil as an old well known remedy. The gynocardate of Sodium and the Morrhuate of Sodium have also been largely used.

Vaccines and nastin series of preparations have not been uniformly successful.

Anthrax or Splenic Fever.

Anthrax or Splenic Fever is an infective disease due to the presence of a comparatively large bacillus, which multiplies rapidly in the blood of its host, and may be easily cultivated outside the body. The bacillus cannot develop unless it obtains a free supply of oxygen, and spores are never developed in the bacillus that grows in the blood. However, where the bacilli make their way from the lungs into the mouth, or from the bowels, and are discharged, spores may be readily formed. Thus, an infected animal may infect whole herds or flocks and render the pasturage infective. A diseased animal, therefore, should be at once killed and either burnt, or buried 6 ft. or 7 ft. deep. Dung from infected animals, or blood, may be rendered harmless with 5 per cent. carbolic acid.

Sheep and oxen, which readily take Anthrax from eating infected materials, are but slightly susceptible when the bacillus is introduced into the tissues through a wound; but rabbits, guinea-pigs, mice, etc., are rapidly susceptible when the disease is inoculated.

In man, Anthrax commonly affects butchers and those who attend on animals, the infectious material obtaining access to the body through a wound—often a very slight one. A man has a scratch, probably on his face, or one of his hands or arms, and in killing or attending to an infected animal, inoculates himself. In from one to three days irritation is noticed at the point of inoculation. A day later there is a very small blister (containing clear serum) in the centre of an inflamed area. Then the contents of the blister become brown, and other blisters form round it. Gradually, a browny-black eschar is formed, indicating the beginning of an area of mortification. Before the nature of Anthrax was understood, this used to be called a malignant pustule; if this be promptly and freely excised, and the wound well cauterised, the disease will be effectually cured. If this be not done, and the inflammation be allowed to proceed, a considerable area becomes affected, part of which mortifies, and probably, sooner or later, the bacilli find their way into the system, giving rise to general Anthrax, as indicated by symptoms one associates with "blood poisoning."

Wool-sorters' disease (so called because it especially attacks persons employed in processes of sorting various wools and hairs in worsted manufactories) is Anthrax derived from infected wool and hair. The disease was long known under this name at Bradford, though not recognised as Anthrax; and about 1863, when Van mohair* was introduced as a textile fabric, the cases became more numerous. The disease occurred in two forms: that characterised by the malignant pustule already referred to, or by a minor pustule or boil, and that having no external lesion.

* The fleece of the goat inhabiting the Van district in Asia Minor.

"Internal Anthrax" so called, which among wool-sorters appears to be more common and more fatal than the other form of the disease, has ordinarily a rather longer incubation period. After, say, from two to twelve days, chilliness, profuse perspiration, flushing of the face, and shortness of breath, etc., indicate the onset, and these symptoms are somewhat suddenly followed by stormy toxic manifestations characterising the fully developed disease, high fever, delirium, cramps, purging, vomiting, etc., usually followed by the death of the patient in from two to five days. In cases not fatal at this time, improvement begins about the sixth day. Even after much improvement the patient may have a relapse, and succumb to secondary inflammatory processes, in which the lungs are especially apt to be involved. There are, however, cases of internal Anthrax in which the disease is very mild, the symptoms being headache, depression, nausea, restlessness, dimness of sight, constriction of the chest, and some cramps in the calves. Often, quite early in the disease, symptoms of various acute local congestions arise. The lungs are specially apt to be affected, and the physical signs of that condition with the occurrence of a copious frothy blood-stained expectoration are noted. Pleurisy, too, sometimes comes on, an extraordinary amount of serum being rapidly effused into the pleuræ. The spleen is usually enlarged. In the intestinal form which very rarely occurs, the symptoms are those of intense food poisoning *e.g.*, severe vomiting, diarrhœa, convulsions, etc.

By what channels do the bacilli reach the system ? In the case of butchers and attendants on cattle, infection appears to be usually *through a wound* but, no doubt, occasionally through the alimentary tract. Wool-sorters handling dirty fleece, wool, or hair, work in air polluted with dust and, if the animals from which the fleece comes have had Anthrax, the dust may infect through a wound or the alimentary tract, or it may be inhaled and reach the system through the respiratory tract.

The *chief remedial measures* recommended for the *relief of wool sorters* are to the following effect :—

(1) Bales of suspected wool or hair should, before being opened, be steeped in water for ten or twelve hours, and in case the bales do not freely admit water, they should be opened therein.

(2) After this the wool or hair should be placed in a solution of soap in water (about 120 deg. Fah.) and washed; then passed through the rollers and sorted while still damp.

(3) The sorting-rooms should be well ventilated, the floors swept daily, the walls and ceilings thoroughly cleansed once a quarter, and the walls washed once a year with lime-wash mixed with carbolic acid.

(4) No wool, hair or other material should be kept in a sorting-room so as to interfere with the proper ventilation thereof.

(5) No meals should be taken in a sorting-room nor food kept there, and proper provision should be made for sorters to wash in or near the sorting-room.

Measures based on the Anthrax Prevention Act of 1919 of England may be introduced. The chief feature is that shipments of wool and hair and all goods mixed with them from countries known to be infected are considered as infected goods and have to be disinfected at the landing port.

The "Duckering" process is a valuable method of dealing with suspected wool and hair. This consists of four stages: (1) Warehousing, (2) Disinfection, (3) Rebaling and (4) Recovery of grease from the effluent.

The 2nd stage comprises—(*a*) Preliminary: Agitating the material with suitable rakes for 30 minutes in an alkaline soap solution at 102°F. This cleans the wool and exposes the

spores (*b*) Disinfection: Treatment for 20 minutes in a 2·5 p.c Formalin solution, the immersed stuff being agitated all the time. This destroys the greater part of the spores. (*c*) Drying the wool in hot air at 160°F. This kills off the remaining spores. (*d*) Cooling—in special machines by currents of air. The wool is kept for some days to ensure the destruction of any spores that have escaped formalin solution.

In the case of hides in addition to measures on the lines mentioned, the following steps should be enforced:—

(1) Dry hides should be covered in canvas bales and man-handling reduced to the minimum by the employment of machines wherever possible.

(2) Wet hides should replace dry hides.

(3) Contact of the hides with the bare skin should be reduced as much as possible by the use cf gloves (to be disinfected after use) and prohibition of carrying of hides on the shoulder.

The duties of the Local Authority as regards Anthrax are to disseminate information about it; to see that all cases in cattle or sheep are duly reported and dealt with so as to prevent the spread of the disease; to investigate all cases occurring in man, and to see that all preventive measures are enforced as required.

Men are infected during the process of skinning diseased animals.

ANTHRAX ORDER OF THE BOARD OF AGRICULTURE.

Dung and litter are to be burnt, or disinfected and buried.

Carcasses must be buried in lime with the skin on, at a suitable place at which animals will not have access, and at a depth of not less than 6 feet below the surface. Before a carcass is removed for burial, all the natural openings must be plugged with tow or other suitable material saturated with a disinfectant.

Several cases of Anthrax have occurred due to infection contained in shaving brushes. The following method of disinfection is recommended by the Government of India :—

> "Thoroughly wash the hair of the brush with soap and warm water to which a little washing soda has been added, rinse in warm water and then immerse overnight in a disinfecting solution consisting of either perchloride of mercury 1 in 10,000 or formalin 2 table-spoonfuls to half a pint of water. After removal from the disinfecting solution, the brush should be washed and then allowed to dry before use. The disinfecting solution should initially be at a temperature slightly above the body heat and care should be taken not to allow the hairs of the brush to come in contact with the hand while under disinfection."

Erysipelas.

Erysipelas is characterised by a spreading inflammation of the skin (or mucous membrane) due to the presence of the streptococcus erysipelatis. After infection, no symptoms are manifested for three to five days. About the time the swelling and redness of the skin begin, there is fever and langour, often headache, shivering, and vomiting. The area generally attacked is some part of the head (the first patch being on the lip, cheek, scalp, etc.) and there is often some sore throat. The fever is remittent in character, but present to some extent till the inflammation ceases to spread. Occasionally the inflammation is very slight but, not infrequently, continues to spread for ten days. Where it is spreading, there is a raised red line, and in rear of this redness the swelling shades off to the part attacked earliest which has recovered. Thus while the disease is advancing in one part it is receding in another. The inflammation at a particular part lasts about five days. Sometimes the disease re-appears during convalescence.

Debilitated persons, puerperal patients, drunkards, and those suffering from wounds, are specially liable to attack and often suffer severely and fatally. In bad cases there may be typhoid symptoms and death from exhaustion, or head symptoms and death from coma, etc. The scarfskin is shed at the parts attacked, and the particles of shed skin carry the infection, as they do in Scarlatina. The contents of the blisters, which form and burst, must also be regarded as infectious.

In very young children the disease may commence at the vulva, and in infants the navel may be the first part attacked. Such cases seem specially likely to prove fatal.

Erysipelas is infectious from the beginning of the inflammation till desquamation is finished, and the parts affected are absolutely clean; commonly this period is a little more than a fortnight.

A person exposed to infection is safe after a week's quarantine.

Cases of Erysipelas certainly require isolation, and are well suited for hospital treatment, where accommodation is available. The infected room, clothing, etc., should be promptly disinfected. Infectious particles may be retained in clothes and carried short distances.

In Erysipelas, as in Scarlatina, special efforts may be needed for the protection of surgical and puerperal cases from risk of infection.

Tetanus.

Tetanus is a specific infective disease, the symptoms of which are not unlike those produced by the poison, Strychnine.

It may ensue from any wound in any part of the body, in any state of the wound, or without any apparent wound, occurring however, more frequently when the wound is in a part exposed to earth or dirt. The disease is due to the introduction into the system of amicro-organism present

in soil taken from the streets or cultivated land. The spores of this organism, protected from air and light, may retain their vitality for a year or more.

The Tetanus bacillus has not only been detected in earth, but in the dirt between the boards of room-floors, and in animal excrement, especially that of the horse. The bacilli have been found to a depth of two meters from the earth surface, but not lower; they grow and multiply in manure, fields and in the stable. Sheep and oxen are often affected. As regards human beings, the disease is most common among agricultural labourers, gardeners, soldiers on campaign, bare-footed children, etc. The bacillus forms its poison exceedingly slowly, and the organism is ordinarily soon destroyed by the tissue cells.

Tetanus appears never to be produced through the bacillus being swallowed, but always through its being received into a wound; the so-called idiopathic attacks being cases in which the wound has been so slight as to escape notice. In the human subject, the period of incubation (*i.e.*, before there are even local spasms) is usually between 8 to 12 days, but may be very much longer, especially in those who have received prophylatic treatment. The bacilli remain localised entirely in the region of the wound, but the poison they generate is absorbed from the seat of inoculation and widely diffused. The shorter the incubation period, the more severe the disease.

The spores may remain latent in the tissues till long after the wound is healed, and yet finally develop into bacilli which in turn make the toxins capable of producing the muscular spasms and the characteristic lock-jaw.

If the first spasms are not, as frequently they are, in the neighbourhood of the wound, they are in the muscles of the neck, jaw and face. If the symptoms go no further, the patient commonly recovers; if the muscles of the back or side or abdomen become affected, a fatal issue may be looked for.

Prophylaxis.—There is not much the Sanitary Authority can do, except by diffusing a little useful information upon the subject. People are so ignorant of the true nature of Tetanus, that it is usual for country folk to apply earth to a wound and to tie up the wound with the earth in contact, probably with the idea that earth will check the bleeding.

Sanitary authorities should, by such means as are in their power, instruct the people that in respect of wounds, as in all other matters, infinite cleanliness is of the first importance. Anti-tetanic serum may be used as a prophylactic measure, 500 to 1500 units being injected intra-muscularly at the earliest possible moment followed by four injections of 500 units each at intervals of one week.

Measles.

Definition.—A specific infectious fever, characterised by catarrh of the respiratory passages, the presence of Koplik's spots on the mucous membrane of the cheeks, a papular eruption on the skin and a special liability to pulmonary complications.

Etiology.—The organism is probably a filter passer. Contagion is conveyed by the nasal secretions and breath; also by fomites, or by a third person. The subject infected with Measles remains, to all appearances, quite well for ten days. Then come the introductory fever and catarrh. The eyelids and the lining of the nose and throat are inflamed. The eyes water, there is a copious discharge from the nostrils, and commonly a cough. There may be vomiting, as in Small-pox, but the back pain so characteristic of Small-pox is absent. Usually, four days after these symptoms begin, the eruption appears.

The eruption at first consists of minute specks ('Measles' is derived from a German word maser, a speck), which can be barely felt as raised above the rest of the skin surface, and these run together in patches, more or less crescentic in shape.

The eruption commences on the face, neck and arms, and takes two or three days to come out. By the time it has reached the legs, it begins to decline on the face, getting browner as it fades. Wherever the eruption has been, the cuticle comes off like scurf. In Measles, as in Small-pox, a person exposed to infection should be quarantined for a clear fortnight, and if, at the expiration of that time, he manifests no symptoms of illness, he may be considered safe. The patient may be regarded as *infectious from the appearance of the earliest symptom till three or four weeks after the appearance of the rash*. If care has been taken to cleanse the patient, he is then safe. There seems to be little doubt that the patient is specially infectious during the primary or catarrhal stage.

Rarely a patient suffers from a Measles eruption without any catarrhal symptoms, and sometimes patients exposed to infection manifest the febrile and catarrhal symptoms without there being any eruption. The first is a light form of Measles, the second often a severe form. The disease described as *putrid* Measles (marked by extreme debility, diarrhœa and frequent gangrene) is extremely rare. It is not spread by milk or drinking water, nor is its incidence influenced by sewer gas. Owing to the special infectiousness of Measles for three or four days before the appearance of the eruption, and consequently before the malady is recognised, brothers and sisters and school-mates susceptible to the disease have probably been infected before the patient can be picked out and isolated. For this reason Measles is not ordinarily to be notified.

The infectiousness of Measles does not appear to last for a long time, as does that of Scarlatina. However, little portions of infective matter discharged from the patient may lodge on the clothes of nurses, etc., and convey infection to short distances.

The Health Officer, in presence of an epidemic of Measles, may often find it expedient to use such powers as he possesses

for closing schools. Children from infected families are commonly kept from school as soon as a case is reported.

School Authorities should keep records of the "Measles History" of children attending their schools, so that on the appearance of the first case, those who have not suffered from the disease may be excluded from the school. This would obviate the need for the closure of the whole school when an outbreak occurs.

Another procedure which has often been followed by good results is to close a class-room on the 9th day after the occurrence of the first case, for five days. The susceptibles will be affected by this time. When the class is re-opened, only those who are free from suspicious signs of the disease are allowed to attend.

The serum of convalescents from the disease, though relatively inert for treatment, has been found to be valuable prophylactic. The dose is 3 to 5 c. c. injected intramuscularly and the passive immunity conferred thereby lasts for about a month. The serum collected from 10 days to 3 months after an attack is most effective though in the absence of this serum from an immune adult may be used in comparatively larger doses.

Clothing, etc., known to be infected should be disinfected, and the rooms occupied by patients well cleaned.

Measles is seldom a fatal disease in families comfortably off, but among the poor is very fatal, the main difference being that well-to-do people understand the importance of keeping the patient warm, and the poor do not.

Rubeola, or Rubella, better known as *German Measles,* or Epidemic Rose Rash, remains latent for about thirteen days, then there is a day or two of malaise or feverishness, and finally the rose rash, which more nearly resembles Scarlatina than Measles. A person exposed to infection should be quarantined for sixteen or seventeen days, and if at the end

of that time he is quite well, he may be regarded as safe. Rubeola resembles Measles in its exceptional infectiousness during the very earliest stage, and before the disease can be diagnosed. The patient ceases to be infectious after the rash has faded, and all branny skin is washed off, say, a fortnight after the rash began to appear.

The infectiousness of Rubeola has probably even less lasting power than that of Measles, but here also portions of infected matter may be carried on clothes to short distances. Children from infected families should certainly be kept from school. Patients' clothing and the rooms occupied by them should be properly disinfected.

PRECAUTIONS AGAINST MEASLES.

1. Measles is a very fatal disease amongst infants.

2. It is very highly infectious especially in the early stage for several days before the rash appears. The early signs of the disease are coughing, sneezing and redness of the eyes, with some degree of illness. When Measles has occurred in a school, coughing alone should be considered suspicious.

3. A child at school with such marks of illness should be at once sent home, and the teachers, particularly in the Infant Department, should be on the look-out for the first signs of illness if Measles has made its appearance in the school or neighbourhood. The occurrence in a school of any catarrhal illness in a child, if Measles has made its appearance in the school, should be considered sufficient reason for sending the child home till the nature of the illness has become plain.

4. A child suffering from Measles should not be allowed to return to school until four weeks have passed after the appearance of the eruption.

5. Any one attacked with Measles should, if possible, be placed in a separate room upstairs, and the windows opened sufficiently to admit fresh air without allowing the room to get cold. The bed should be placed in that portion of the room in which there is least draught.

6. In view of the high percentage of mortality from the disease, parents are advised in every instance to seek medical advice.

7. The children at home not attacked must not go to school or other place of meeting for three weeks after the appearance of the eruption in the first child and, if subsequent cases occur, not until three weeks after the appearance of the eruption in the last child attacked.

8. Where a case of Measles has occurred in a house, a careful watch should be kept on the other children, so that, on the first appearance of the signs of illness, they may be kept at home and properly treated.

9. When a child at any house is suffering from Measles, no neighbour's child or neighbour accompanied by a child must be admitted, nor should the child ill with Measles be allowed to play with other children for a month after the appearance of the rash.

10. *Disinfection.*—Before the child attacked returns to school, the following measures should be carried out. All articles of clothing worn by the sick child and the bedding and hangings of the sick-room should be washed and put out to air for some days. All washable articles of furniture in the room should be washed. The walls of the room should be lime-washed. The floor should be thoroughly scrubbed and disinfected. The windows should be left open for several days and the window curtains removed so as to admit as much light as possible. The skin of the child who has been ill should be thoroughly cleansed by several washings with soap and warm water.

Whooping Cough.

The virus is chiefly spread by the sputum, the infection being most probably by the "droplet method". Fomites, etc., play a very minor part. The bacillus Pertussis has good claims to be considered the causative organism.

The onset of Whooping Cough is in many cases so insidious that it is difficult to say for how long it has been latent. It is probable that the latency does not ordinarily exceed four or five days; then follows the catarrhal stage, lasting from three days to a week (occasionally a fortnight), and finally the paroxysmal cough and whoop. The cough consists of a number of expiratory motions in rapid succession followed by a long inspiration, the air making a whooping noise as it passes through the partly closed rima glottidis, and this may be repeated two or three times during a paroxysm till mucus is forced up, or the child vomits. During the intermission, if the disease is uncomplicated, the patient (usually a child) appears quite well. The violence of the paroxysm appears to depend on the difficulty of getting up the expectoration. The frequency of the paroxysms varies much in different cases and at different times. The duration of the disease is from about three weeks to three months. Relapses are not uncommon, and these may occur more than once.

Whooping Cough may be complicated with Bronchitis or Emphysema, or hæmorrhages under the meninges or conjunctiva or in other parts; not infrequently small ulcers appear under the tongue.

As the disease is infectious from the beginning of the catarrah, when probably Whooping Cough is not suspected, till mucus ceases to be coughed up, it is not surprising that it spreads rapidly, and is the most fatal of all diseases of children under five years of age.

A person exposed to infection and manifesting no symptom of catarrh for a clear week is probably safe. In some districts in Europe, Whooping Cough is required to be notified. However, notification is not of much service in respect of a disease which is infectious for days before it can be recognised.

Of course, children from infected houses should be kept from school; and in the presence of a severe outbreak, it may be expedient to close the local schools.

PRECAUTIONS AGAINST WHOOPING COUGH.

1. Whooping Cough is a fatal disease amongst infants.

2. It is highly infectious, and when fully developed, is characterised by the well-known crowing sound. At the commencement of the disease, there may be nothing to indicate that it is coming on, except some degree of feverish cold taken along with the fact that it has been preceded by Whooping Cough in other children. Sometimes frequency of cough announces its approach.

3. A child at school, in whom there is reason to believe that Whooping Cough is showing itself, or who has the disease well-marked, should be at once sent home, and the teachers should be on the look-out for fresh cases. Any illness in the Infant Department following on the occurrence of Whooping Cough should be viewed with suspicion and the child sent home.

4. In looking for the occurrence of Whooping Cough among children under their charge, teachers should particularly observe that the disease may be ushered in by no observable symptoms, except perhaps coughing, and that any appearance of illnes should be considered sufficient ground for sending a child home for a few days once the disease has made its appearance in the school.

5. A child attacked with Whooping Cough should, if possible, be isolated in a room upstairs, and the window opened sufficiently to admit fresh air without allowing the room to get cold.

6. The other children in the house should not go to school or other place of meeting, such as places of public worship or amusements, until three weeks have elapsed since the commencement of whooping.

7. When one child in a household has been attacked with Whooping Cough, the others should be watched, and any appearance of illness especially with coughing, should be regarded as probably indicating Whooping Cough, and the child treated in the same manner as the one first attacked.

8. When a child at any house is suffering from Whooping Cough, no child or neighbour accompanied by a child must be admitted into the house; nor should the child with Whooping Cough be allowed to return to school or play with other children until the "whoops" have ceased to be observed.

9. The matter coughed or spat up by the sick child must be regarded as infectious, and should be received into pieces of rag which should be at once burnt. Discharges from the nostrils should be treated in the same manner.

10. In all cases of Whooping Cough, medical advice should be obtained until the child is out of danger.

11. *Disinfection.*—Before the child attacked returns to school, the following measures should be carried out. All articles of clothing worn by the sick child and the bedding and hangings of the sick-room should be washed and put out to air for some days. All washable articles of furniture in the room should be washed. The walls of the room should be lime-washed. The floor should be thoroughly scrubbed. The windows should be left open for several days and the window curtains removed so as to admit as much light as possible.

Diphtheria.

Diphtheria, like Scarlatina, remains after its inception patent for two to five days. Like Scarlatina, also, it is a disease mainly affecting children at school-age (three to twelve years), and occasionally it is so mild that no serious disease is suspected, and the patient never comes under medical treatment. The initial case in an epidemic is thus often an unsuspected case. The first symptom attracting attention is commonly a sore throat and, sometimes with this or before it, a patchy, red rash about neck and chest. Next a false membrane forms, extends and thickens and in course of time is shed. However, the diphtheritic membrane need not be in the throat—it may be in the windpipe or nostrils, or the membrane is not peculiar to Diphtheria even when it is in

the throat. The difference between Diphtheria and some other diseases which resemble it (and which Bretonneau himself would doubtless have called Diphtheria), according to the modern view, is that Diphtheria is the disease due to infection by the bacillus of Klebs and Loeffler. The bacillus starts the disease, and the fever and other symptoms following are mainly the result of absorption of the chemical poison produced by the living bacillus. After the membrane has been shed, or before, an attack of Diphtheritic Paralysis is not infrequent. Indeed, Paralysis may follow in cases where Diphtheria was so mild as to be unrecognised.

Diphtheria is infectious from the inception of the disease till the throat is quite healthy. In cases sent to hospital or carefully treated, this time will not ordinarily exceed five weeks.

A person exposed to infection, who remains well after a week's quarantine, may be considered safe.

Diphtheria is not usually notified early, but prompt isolation will often prevent the spread. Isolation hospitals are particularly useful for cases of Diphtheria, as the disease often occurs in insanitary dwellings, from which it is of the first importance to remove the patient.

The house where a case occurs should be examined for defects and, if discovered, these should be remedied. The disease seems to favour damp houses. The room, clothing bedding, etc., should be disinfected, and the children from infected houses should be kept from school.

Schools may be closed with a view to check the spread of Diphtheria, when nothing worse than what appears to be sore-throat is prevalent among the scholars; and children suffering from sore-throat, however mild, should be kept from school. The disgusting way in which slates are often cleaned, the transferring of sweets from mouth to mouth, and the use of drinking cups common to many, are some of the methods by which Diphtheria may be spread at schools.

In investigating Diphtheria, it is often easy to trace the disease from case to case through personal intercourse, whilst it is usually most difficult to offer a reasonable explanation of the first case. The initial case or cases may have come from a specifically infected carrier and even from cats, domestic fowls, or pigeons. As regards milk, it seems to be able to initiate the disease and may certainly spread it. When the bacillus is once introduced into milk, it readily multiplies even at ordinary temperatures. There is ground for believing that occasionally the cow through infection of the udder, yields infective milk.

Persons who have just had or are recovering from Scarlatina or Measles, are specially liable to take Diphtheria, and so apparently are women who have been recently delivered.

The infection, of Diphtheria like that of Scarlatina, can be retained in clothes, etc., for a long time.

The diphtheritic contagion is given off from the body in the secretions from the mouth, nose and throat, and clings to infected articles of clothing and bedding.

Epidemic prevalences of the disease commonly commence in September, reach their highest point during October and November, and then subside slowly during the following two months.

The commonest method of the spread of this disease seems to be the " droplet method", the germs being carried from person to person in minute drops of saliva, sputum or nasal mucus expelled in coughing, sneezing, etc. " Carriers " who may have previously suffered from this disease in a recognisable form and especially those that have had a mild attack and have therefore been overlooked are also responsible for spreading infection.

PROPHYLAXIS.

Among the prophylactic measures apart from thorough isolation of the patient and proper disinfection of articles

likely to have been infected, the following are advisable especially in cases of schools, dormitories, etc.

I. *Production of passive immunity.*—This is of use when immediate measures are indicated. 500 units of anti-diphtheritic serum are injected subcutaneously. Immunity reaches its height in 24 hours and remains at a high level for 3 to 4 weeks. There are certain drawbacks to this method. (1) The immunity is short lived, (2) Danger of Anaphylaxis in subsequent years, (3) Interference with the development of active immunity, (4) The possible production of "Carriers."

II. *Production of active immunity by the subcutaneous injections of mixed toxins and anti-toxins.*—These mixtures vary in the respective proportions as put up by various makers. The following plan would recommend itself to most. 3 injections in all are given at intervals of one week. The dose is 1 c.c. for an adult. For children it may be increased from .25 c.c. to 0.5 c.c. and 1 c.c. The first injection contains equal parts of the toxin and anti-toxin, the second, two parts of toxin to one of anti-toxin and the third, three parts of toxin to one of anti-toxin. Some local reaction is common. Immunity is said to develop in 3 weeks and lasts 6—7 years. This measure should be carried out in combination with the Schick test and examination of the throats of contacts. It is obviously of little use when urgent measures are indicated but is most useful to control epidemics.

The Schick test depends on the theory that 1/30 unit of anti-toxin per c.c. of blood confers immunity. This prevents reaction to 1/50 minimum lethal lose (guinea pig) of Diphtheria toxin introduced into the skin. 0.2 c.c. of normal Saline containing 1/50 M.L.D. is injected intradermally into the skin of the forearm (flexor surface). The other arm is similarly injected with toxin heated to 75°C. for ten minutes so as to destroy its virility.

A positive reaction is indicated by the appearance of a sharply circumscribed red area ½—1″ in diameter, appearing in

24 hours and reaching its maximum in 3—4 days. The area may remain pigmented upto 7—10 days. The pseudo reaction is less circumscribed, appears earlier (18 hours) reaches the maximum in one day and fades away in 3 days or so. A negative reaction shows that the person is immune but it does not exclude carriers.

A positive reaction indicates susceptibility and calls for prophylactic measures. Combined with the examination of the swabs from the throats of all likely contacts and incubates, this test provides very valuable indications. These may be summarised as follows :—

I. *Group.*—Schick positive ; swab negative.

II. *Group.*—Schick positive ; swab positive and bacilli avirulent.

These persons are susceptible and should be removed from the source of infection and isolated and watched. They are not in iminineut danger of getting the disease.

III. *Group.*—Schick positive ; swab positive and bacilli virulent. These are like the first susceptible but also probably in the incubation period. Passive immunity with anti-toxin would be indicated in such cases.

IV. *Group.*—Schick negative ; swab negative.

V. *Group.*—Schick negative ; swab positive and bacilli avirulent.

These are fully protected and not harmful to anybody. No special measures are indicated in their case.

VI. *Group.*—Schick negative ; swab positive and bacilli virulent. These are themselves secure but are the most dangerous from the point of view of the community, being active carriers. They should be isolated as early and as fully as possible and suitably treated.

The value of this combined method lies in the fact that the potential sources of danger and the potential sufferers are

detected with certainty and some ease and wholesale administration of anti-toxin—a costly and an unpleasant process—need not be resorted to.

Ramon has treated diphtheria toxin with heat and formalin and introduced the product under the name of "Anatoxin" to remedy the drawbacks of the toxin—anti-toxin method. Immunity is said to develop in 4—6 weeks with a very high proportion of certainty.

More recently, Glenny and others have used a toxoid treated with alum under the name of "Alum-toxoid." This product is claimed to be superior to the toxoid-anti-toxin mixture in as much as it produces immunity more rapidly and hence would be valuable during epidemics. Its drawback lies in the unpleasant reactions which follow its injection and which are more severe than those of the toxoid-anti-toxin mixture.

Scarlatina.

The specific organism is probably a hæmolytic Streptococcus isolated by Dick and others.

Scarlatina after its inception commonly remains latent for two or three days, when the patient is feverish for a day or two and complains of headache, slight sore-throat and stiffness of the neck. These symptoms are followed by an eruption beginning in minute points, but these become so numerous as to produce a general redness of the surface. The eruption is brighter in colour and less elevated than in the case of Measles. The rash begins on the face and neck and spreads over the whole body, and may be expected to last three or four days before fading. Probably, about a week after the first symptoms the peeling begins. This is a very slow process lasting many weeks. The skin is usually shed in fine scales from the head and body, and in flakes from the extremities. With the early symptoms, a white fur gathers on the tongue, and through this appear the red swollen papillæ, then the white fur clears away,

and the whole tongue looks exceptionally red and rough. The throat gets very red, and the tonsils swell and redden. Then a whitish exudation may appear, with ulceration or even sloughing. The degree of severity and danger differs much in different cases and in different epidemics. In so-called simple Scarlatina, the florid rash may be accompanied by little or no sore-throat; and in malignant Scarlatina, the rash is usually late and imperfect or absent, while the throat symptoms or head symptoms are so severe as to cause death. Scarlatina is infectious from the earliest symptom till desquamation is complete and the patient absolutely clean. This ordinarily takes not less than five or six weeks, and occasionally nine or ten.

A person exposed to infection should be quarantined for a week, and if he then shows no signs of illness he may be considered safe. Though a case of Scarlatina is not usually notified till the rash has begun to appear, the disease is so slightly infectious at first, that prompt isolation will generally prevent the spread of the disease. Isolation hospitals are probably of more use for isolating cases of Scarlatina than for any other disease. The room, clothing, bedding, etc., should then be promptly disinfected; and children from infected houses should be kept from school till safe.

In the presence of an epidemic, it may be well to take steps for closing the local schools; but when a good hospital is provided, this will not be often needed.

Return cases (cases re-appearing in households shortly after the return of a patient from hospital) are not always easy to account for, but they would be very rare if great care were always taken to keep patients in hospital till all peeling had finished, and any discharge they might have from ears or nose had ceased. Infectious particles may be retained in clothes, etc., for months.

That a person suffering from a wound or injury or a woman recently delivered, is specially liable to become infected

with Scarlatina is a well-established fact. It is reasonable, therefore, that special efforts should be made for the protection of surgical and peurperal cases from the risk of Scarlatina infection.

In investigating an outbreak of Scarlatina, the frequency with which the disease has been *spread by milk* must be borne in mind. The milkers, collectors, or distributors of the milk may have contaminated it, the vessel in which the milk is delivered may have been recently in an infected house; and there may be some ground for believing that occasionally the cow has an allied disease and yields infective milk. Attempt to immunise susceptible persons with Scarlet fever anti-toxin have been made. The results are not very encouraging. The susceptibility is determined by intradermal injection of a minute quantity of the toxin of Dick's streptococcus. Local erythema increasing in size upto 24 hours and then fading away indicates susceptibility. (Dick test.)

Chicken-pox.

Chicken-pox patients (like Small-pox patients), after having caught the disease, remain to all appearances quite well for eleven or twelve days, and they are slightly feverish and indisposed for two or three days. The premonitory fever and indisposition may be absent. About the fourteenth day appears the eruption usually commencing on the shoulders, neck and breast and often spreading on the face. The eruption is one of transparent vesicles, like little blisters produced by boiling water. The blisters come out in crops, the earlier ones shrivelling while the new ones are forming. Blisters which do not shrivel quickly get slightly opaque. A person exposed to infection, remaining well for a fortnight, is ordinarily safe. The patient is infectious from the first symptoms till all the scabs fall off. Chicken-pox is commonly a disease of children, but adults are not infrequently seen suffering therefrom.

A district in which infectious diseases are compulsorily notifiable will do well to add Chicken-pox to the list of diseases required to be notified. If this be not done, sooner or later, some mild case of Small-pox may escape notice.

The children of a family in which one is suffering from Chicken-pox should be kept from school, for the infectious particles may be conveyed in clothing. The patients room should be cleaned, and his clothes, etc., disinfected.

An attack of Chicken-pox is occasionally very severe. It is not prevented or modified in any way by vaccination.

Influenza.

Influenza is latent ordinarily for three or four days, a day more or less being not uncommon. Occasionally, the latency appears to be less than twenty-four hours. The onset of the attack is marked by pain coming on suddenly in the head and back, and this is followed by the usual symptoms of a bad cold. There is some fever, a furred tongue, foul breath and great prostration. After four or five days the fever subsides, and the patient is left weak and depressed, and liable to fits of chilliness followed by sweats. Not rarely there is some delirium, even at an early stage.

Influenza does not always correspond to this description, as cases occur where the disease is much more severe in the lungs, cases in which drowsiness is a prominent symptom from the first, in which there is no fever, cases in which the disease closely resembles Typhoid Fever, etc., etc. The intemperate and the overworked seem specially liable to attack, and likely to have the disease severely.

The influenza patient and the discharges from his nose and throat are infectious from the onset of the disease, till he is well enough to resume his occupation ; this will ordinarily be in about ten days, but it may be three or four weeks.

A person exposed to infection and manifesting no symptom for six days is probably safe.

It goes without saying that, after the recovery of the patient, infected rooms and clothing should be disinfected.

The following memorandum from the Government of India, issued by the Government of Bombay in 1919, gives in detail the mode of spread and the measures for the control of Influenza.

During 1918 a peculiar and exceptionally widespread epidemic of Influenza appeared, which affected the inhabitants of practically every continent. This epidemic not only caused, directly or indirectly, a very large number of deaths which in India alone were computed to exceed five million, but left behind it a legacy of minor ailments with consequent national debility. The economic effect through the disorganization of trade cannot be estimated, but must have been very great.

Although previously severe and worldwide epidemics have been known to occur, in none were the spread and mortality so alarming as in the epidemic of 1918. So far as it affected India, the epidemic of the summer months assumed a mild form of the disease. After an apparent departure, it re-appeared in a virulent and very fatal form during the autumn months and then seemingly disappeared at the end of the year. In fact this was not so, as small localized epidemics have occurred and sporadic cases have continued throughout the present year. As the experience of epidemics in England and elsewhere have been that recrudescences at intervals are liable to occur, it is highly desirable to be prepared for such an event in India.

With this object in view, this memorandum has been prepared, which sets forth opinions founded upon the valuable observations made during the 1918 pandemic and contained in the world's medical literature, and which

furnishes in the abstract a list of the preventive measures that promise to give the best results in India. It is not possible to say that even with the adoption of the suggested measures it will be possible to prevent the disease becoming epidemic but it can safely be asserted that the observance of these rules will diminish the incidence of the infection.

The organism responsible for the epidemic of Influenza has not been definitely identified. The weight of evidence still points, however, to the bacillus, called the bacillus of Pfeiffer being the cause: at all events it is intimately associated with the disease. Judging from clinical and epidemiological standpoints, the disease which appeared in India was identical with the last great pandemic of Influenza which occurred in 1890-91. In the absence, however, of definite proof of the casual organism, the statement is a surmise although a probable one.

Influenza is a disease which exhibits an intense infectivity and an incubation period which is relatively very short, *i.e.*, from 6 to 48 hours. It is commonly believed that the disease is spread by the infected secretions of the throat and nose of infected persons finding lodgment in the nose and throat of uninfected people. The commonest means by which this occurs is by coughing and sneezing especially in confined spaces. Methods of prevention, then, will consist of preventing communication of infection by these channels.

These measures may be considered from two standpoints.

I. Procedure recommended for Military, Municipal and other Administrative Bodies.

It is realized that no legislative measures can be adopted in most communities and moreover since the limitation of an epidemic of this nature depends more upon individual than upon legal enactments, the following general recommendations are made.

A. Education of the public with regard to such facts as the following :—

(1) The golden rule is to keep fit and avoid infection as much as possible.

(2) The way to keep fit is to cultivate healthy and regular habits, take regular exercise, to eat good food, and to avoid fatigue, chill and alcoholic drinks. Healthy living does not of itself ensure against attack, but it makes the patient better able to withstand the complications which may kill.

(3) The earliest symptoms of Influenza are usually those of a severe feverish cold: it is most infectious in the earliest stages; it is spread by discharges from the mouth and nose; it kills mainly by its complications and every person suffering from the disease, no matter of how mild a form, is a danger to others. For these reasons coughing, sneezing, spitting and hawking in public places are dangerous.

(4) It is not always possible to avoid infection, but the risks can be lessened by—

(*a*) healthy living;

(*b*) working and sleeping in well-ventilated rooms;

(*c*) avoiding crowded gatherings and close ill-ventilated buildings, or carriages;

(*d*) wearing warm clothing;

(*e*) irrigating the nose with saline solution (*see* later);

(*f*) wearing in certain instances a mask of prescribed pattern (*see* later);

(5) Do not lay too much emphasis upon drugs in the hope of preventing infection.

(6) Those attacked should—

(*a*) go to hospital or go home, go to bed and keep warm;

(*b*) call in a doctor, where possible ;

(*c*) occupy, if possible, a separate bedroom or a bed that is screened off from the rest of the room ;

(*d*) when coughing or sneezing hold a handkerchief in front of the mouth, the handkerchief should be boiled or sterilized in antiseptics, or burnt, if of paper. Similar attention should be paid to linen, etc., soiled by discharges, by persons suffering from common cold or catarrh, as it is undoubted that in apparently healthy communities the infective agents of Influenza are frequently present in such persons ;

(*e*) do not return to work, through a sense of duty, until convalescence is well established, and during convalescence be extremely careful to avoid chill which may induce a relapse or complications ;

(*f*) avoid meetings and places of entertainment for at least one week after the termperature has become normal.

Such education we believe should be made compulsory in all schools and colleges ; the press might aid by giving publicity to such measures as are recommended for adoption.

B. The closing of meeting places, schools, colleges, cinema halls, dancing halls, skating rinks, churches, etc.—Regarding these measures universal recommendations cannot be made. The widespread depression in the minds of the general population during epidemic times must be remembered. Such depression may be a predisposing factor in the occurrence of the disease, and it is felt that if measures were passed such as closing all theatres and resorts of amusements, the effect

on the public health might be worse than if nothing was done at all.

Again, take the instance of schools; if children were taken from well ventilated schools, they might add to the congestion of already overcrowded houses. This matter must be left to individual localities to settle, bearing in mind that it is necessary to limit the number of unnecessary gatherings and that it is necessary to keep up the morale of the public. In this connection attention should be drawn to the danger associated with travelling in cars and carriages. It is believed that a fertile source of the spread of infection occurs in overcrowded railway carriages, tram-cars, etc. The prevention of overcrowding should especially be insisted on at such times and scrupulous cleanliness of carriages and cars be enforced. It is believed that much mischief was done in the last epidemic by the exodus from cities of panic stricken populations, and facilities for such exodus should be prohibited.

C. *The wearing of face masks.*—Opinions are divided as to the efficacy of this measure: it largely depends upon their construction. The masks should be of very close woven muslin or gauze. Recent work in America would seem to point to a gauze with a mesh 44 by 40 to the inch; three to six layers of fine muslin should form the mask and they should be applied so as to cover the nose and mouth completely. The gauze is cut 8 inches wide and 23 inches long. Details of the method of manufacture are given in a foot-note.*

* The gauze 44 by 40 mesh is cut 8 inches wide and 23 inches long. The sides and one end are turned down one quarter inch. It is folded-twice, the unturned end first making a 7 inch square. The opposite diagonal corners are cut off 1 inch and the raw edge is turned in one-half inch. It is stitched firmly all around. A 1-inch dart $1\frac{1}{2}$ inches long is taken up at the middle of each side of the mask. A 14-inch tape is sewed on the opposite uncut corners. This mask has the advantage of covering the nose and mouth and in making the traction on the chin and not drawing on the nose and lips.

The use of these masks should be made compulsory among nurses and attendants in hospitals which admit Influenza patients and might be adopted in houses where cases of Influenza are present and among volunteers and others who come in contact with the sick. The wearing of a face mask, whilst having a certain protective action, exerts an educative influence upon the patients. Though it would be more reasonable for the patient to wear a mask, this is impracticable in view of further impeding respiration which already may be difficult.

As there is a small possibility that droplets of infective matter lodging in the eyes may give rise to the disease, the use of goggles by such attendants may also be recommended.

Another suggested use of face masks is by barbers, dentists, etc., whose occupation brings them into close contact with a number of persons, and who if incubating the disease may otherwise infect their clients.

D. Isolation.—It is feared that insistence upon isolation of Influenza cases in India is impossible. For one thing there is not sufficient hospital accommodation. Every case, however, of Influenzal Pneumonia should be rigorously isolated, as the germs present in post-Influenzal Pneumonia are themselves infectious, altogether apart from the causative organisms of Influenza. Hospitals should attempt to separate uncomplicated Influenzal cases from those suffering from secondary Pneumonia.

E. Sprays and Gargles.—The use of disinfectant sprays and gargles is not recommended. Disinfectants are apt to remove the protective mucus of the throat and mouth to cause irritation of the mucus membranes or lining membranes of these cavities and so predispose to the lodgment of infective material. They can hardly be used strong enough to be protective without causing violent irritation. The use, however, of a solution of common salt one teaspoonful to a pint, might be productive of good results if used as a gargle or

sniffed up the nose, as it will produce an excess of the normal secretions of the nose and throat and this leads to the washing out of micro-organisms.

F. Disinfection.—With regard to the disinfection of infected rooms, it seems fairly established that ordinary cleansing with water, airing and sunning effect as much good as the use of actual disinfectants. In addition as already suggested, all handkerchiefs, sheets and clothings recently soiled (within 48 hours, as drying kills the infective agent) should be boiled or otherwise sterilized. The periodic disinfection on the above lines of public places, *e.g.*, railway waiting rooms, trams, rolling-stock, dak bungalows, serais, etc., which in epidemic times may be taken to be infected, is also strongly recommended.

G. Quarantine.—A limited measure might be practised by local institutions such as resident colleges, schools, asylums and jails. A jail, for example, situated in an epidemic area might by rigid quarantine be reasonably certain of keeping out infection, or at least of delaying its appearance. There was evidence of the efficiency of this measure in certain jails in India during the last epidemic.

H. Notification.—Notification of all cases of Influenza would be obviously impossible. A limited notification might, however, be adopted at ports; some value being likely to result from the notification of infected ships and the prompt removal to hospital of actual cases.

Notification of Influenzal Pneumonia is now compulsory in England and in Australia. This measure in India would only be possible amongst the military and civil population in large towns where the Municipal Act already permits of the notification of all forms of infectious disease.

SPRAYING INFLUENZA CONTACTS.

At the time of the Influenza Epidemic in Bombay, a steam spraying chamber was erected for the purpose of dealing with contacts of Influenza. The main principle was that, by

means of an aspirating device, a suitable disinfectant contained in bottles was sprayed into the chamber by steam jets, to which the bottles were connected. The chamber was of a size which was suitable for treating ten persons at one time. Steam was obtained from a boiler working at 50 lbs. pressure, and arrangements were planned so that the existing boiler with an Equifex disinfector could be made use of. The disinfectant used was a solution containing lysol 5 per cent., normal saline solution 8 per cent., and zinc sulphate solution 1 per cent. The fluid jets were arranged so as to allow one litre of the solution to be delivered in 15 minutes, which was the maximum duration of the sitting for the persons being treated, and instructions were given that the spray was to be inhaled vigorously. Inhalation once a day for three consecutive days was the system then being done, but it was difficult to force contacts to attend more than once, chiefly because the value of the inhalation as a preventive measure was not appreciated. Care was taken to ensure thorough ventilation of the chamber after each sitting, and also prevent the rooms being hot or stuffy during the sitting. A medical officer was in charge of the operations, and was present while the treatment was being carried out, and the District Registrars in charge of Municipal Dispensaries in Bombay discovered contacts and mild cases and persuaded them to take this treatment. Not only contacts of Influenza and mild cases of Influenza, but contacts of other diseases such as Measles and Cerebro-spinal Fever can be dealt with in such chambers if occasion arises.

Prophylactic Vaccination.

A mixed vaccine consisting of B. Influenza, Pnemococci and Streptococci has been tried extensively during and since the pandemic of 1918-19. The incidence of the disease is not affected by inoculation with this vaccine but it prevents the chief respiratory complications and lessens the mortality due to them.

Measures for Organised Relief.

(*a*) Local authorities should have ready lists of their requirements for doctors, nurses, the additional hospital staff required such as sweepers, bhistis, etc., mask makers motor cars, ambulance drivers and volunteers of all kinds necessary for the actual treatment of the sick; and have noted, as far as possible, the actual persons who could prove useful in various accessory capacities. A canvas of private cars, which people are willing to lend as ambulances, might advantageously be made. Further, the names of volunteers for district visiting and localization of cases should be noted.

In this connection too, it would be well for municipalities and other local authorities to entrust the actual arrangements prior to an epidemic and preparatory for it, to some already organised body such as the St. John's Ambulance Brigade Nursing Association, as in addition to the above, hospital requisites must be obtained, *e.g.*, beds, mattresses, etc. Lists of what are available should be made ready.

(*b*) Resources of men and material should be centralized under one central authority.

(*c*) The work of district visitors in a house-to-house canvas, referred to under paragraph (*a*) above, should be co-ordinated. Valuable information would thus accrue as to the actual extent of the disease. These visitors should also be instructed as to the type of case and home which would justify home treatment being adopted, and when hospital treatment is necessary.

A central clearing house or a bed dispensary might be instituted in large towns and severe cases be transferred from these to the hospitals. Hospitals should be warned to admit only severe cases as their resources will be taxed to the uttermost.

(*d*) It is needless to say that all other public health organizations, such as vaccination and plague organization

staff, etc., should be utilized for the various measures of Influenza epidemic control.

The following note has been published by the Government of Bombay prescribing certain temporary regulations for the control of an outbreak and spread of Influenza and acute Pneumonia.

GENERAL DEPARTMENT.

Bombay Castle, 7th May 1920.

No. 5261. In exercise of the powers under section 2 of the *Epidemic Diseases Act*, 1897 (III of 1897), conferred by the Notification of the Government of India in the Department of Education (Sanitary) No. 566, dated 10th September 1919, the Governor in Council is pleased to prescribe *in the Bombay Presidency excluding the City of Bombay*, the following *temporary regulations to prevent the outbreak or spread of Influenza and Acute Pneumonia, namely :—*

1. Appointment of special officer.—In every local area which is threatened with an outbreak of *Influenza or Acute Pneumonia* the District Magistrate, subject to the general instructions of the Commissioner, may appoint either by name or by virtue of his office a special officer or officers to carry out all measures necessary to prevent the spread of these diseases.

2. Notification of outbreak.—(*a*) The District Magistrate shall cause to be published in every town or village in any area infected or threatened with Influenza or with Acute Pneumonia or with a disease suspected to be Influenza, a list of infected towns and villages in that area with the names of the special officers concerned; any area in the towns and villages of which such a list has been published shall be deemed to be an infected area.

(*b*) When any outbreak of Influenza or Acute Pneumonia or a disease suspected to be either occurs in his district, the District Magistrate shall forward to the District Magistrates of neighbouring districts a list of infected towns and villages for publication when deemed necessary. When the outbreak occurs or threatens in a pilgrim centre, he shall in addition send intimation to the District Magistrate of districts from which the pilgrims come.

3. Intimation of cases.—(*a*) In any town or village in an infected area every person shall, on such occurrence coming to his knowledge, give *immediate information* to the Municipal Secretary or to the Revenue Patel of (*a*) any human sickness or death, and (*b*) the arrival of any person from a place declared infected in any list published under regulation 2 (*a*).

(*b*) The Municipal Secretary or Revenue Patel shall, on receiving such information, send intimation thereof to the Mamlatdar or Mahalkari and to the Deputy Sanitary Commissioner of the district.

(c) In the case of any human sickness or death occurring on a railway in an infected area or on the arrival by rail in such area of a person from any place declared infected in any list published under rule 2 (*a*) the chief local Railway Officer in such area shall give intimation as prescribed in clause (*b*) of this regulation.

4. *Segregation and disinfection.*—The special officer may adopt such measures as he thinks necessary for—

(*a*) isolating the patient, and

(*b*) disinfecting clothes, vehicles or other property which have been exposed to infection.

5. *Publication of remedies.*—The special officer shall arrange for the publication, by beat of tom-tom and by periodical distribution of leaflets in the local vernacular, of measures of protection against the disease.

6. *Disinfection of buildings.*—The special officer may require the occupier or owner of any building or enclosure, in which a case of Influenza or Acute Pneumonia or a case suspected to be either has occurred, to carry out such measures as he considers necessary for the purpose of disinfecting or of improving the sanitary condition of such building or enclosure. He is also empowered to enter any building or enclosure and to order its disinfection, if he has reasonable cause to suspect that any portion of it has been recently occupied by a person suffering from either disease.

7. *Bazars, markets, fairs.*—The District Magistrate may order, in the case of an infected town or village, that the *bazar, market or fair be held outside the inhabited* area at such distance therefrom as he may prescribe.

8. *Requisition of buildings.*—The District Magistrate may *take possession of and occupy any vacant ground or building* for the purpose of a camp or hospital or dispensary. Such rent or compensation as may be agreed upon shall be paid to the owner or occupier or other person entitled thereto. In default of agreement, the amount payable shall be decided by arbiters, one appointed by the District Magistrate, one by the claimant and a third by the two arbiters so appointed: a majority decision of the arbiters shall be final and binding on both parties.

9. *Destitute patients.*—The special officer, when he learns that any person suffering from Influenza or Acute Pneumonia is left uncared for, shall arrange to take him to the nearest hospital.

10. *Public meetings.*—If it appears to the District Magistrate that *any public meeting, theatrical or cinema performance or any gathering of persons, in any hall, theatre or public building* is likely to spread either disease, he may, after giving due notice to the conveners or management of such meeting, gathering or performance, *prohibit the holding of the same* for such time as he may consider necessary. He may also close schools.

11. *Spitting in public places.*—The District Magistrate may *prohibit spitting in the streets or any public place or building.*

12. *Public conveynces, waiting rooms, etc.*—In regulations 13, 14 and 15 the term "*public conveyance*" shall be deemed to include tramway and railway rolling stock, and such of the provisions of these regulations as are applicable to public conveyances shall apply, as far as may be, to premises such as waiting rooms, offices, etc., used in connection therewith.

13. *Conveyance of infected persons prohibited.*—No person owning or in charge of a public conveyance shall permit a person whom he has reason to believe to be suffering from Influenza or Acute Pneumonia to enter such conveyance.

14. *Infected travellers.*—If any person while using a public conveyance develops Influenza or Acute Pneumonia, the person in charge of such conveyance shall be responsible for :—

(*a*) removing the person so infected ;

(*b*) arranging for his accommodation and treatment at the nearest place ;

(*c*) notifying the facts to the relatives of the patient and to the local civil authority prescribed in regulation 3 (*a*) ; and

(*d*) properly disinfecting the conveyance used by the patient before it is again used.

15. *Examination of travellers.*—The special officer shall have power at any halting place or station *to enter and examine any person using any public railway conveyance ;* but such examination shall not entail the detention of the conveyance for a longer time than is fixed for its detention at such place or station.

16. *Overcrowding of railway carriages.*—It shall be the duty of every railway servant to remove from a compartment the number of passengers in excess of the maximum fixed for such compartment by the railway administration and to insist on sufficient windows being kept open to ensure proper ventilation.

17. *Co-operation of the Police.*—All Police Officers shall afford the special officer all necessary assistance in carrying out the provisions of these regulations.

18. *Compliance with regulations.*—Every person to whom any order or requisition is directed under these regulations shall duly comply with the same, and no person shall obstruct any one in the performance of any duty imposed by or under these regulations.

19. *Penalty.*—Whoever shall disobey any of these regulations, or any order made thereunder, shall be liable to be prosecuted under section 188, Indian Penal Code.

20. *Short Title ; Extent ; Local modifications.*—The foregoing regulations shall be called the *Bombay Influenza Regulations* and shall apply throughout the Bombay Presidency (excluding the City of Bombay)

subject to the following modification in the case of Cantonments and Hill Stations in charge of Superintendents :—

> In the case of Cantonments substitute " General Officer Commanding " for " Commissioner " and " Cantonment Authority " for " District Magistrate."
>
> In the case of Hill Stations in charge of Superintendents, substitute " Superintendents " for " District Magistrate."

Mumps.

Mumps is characterised by an inflammatory affection of the salivary glands, and of the parotid gland in particular.

As to the length of incubation period in Mumps, the report of the Clinical Society Committee states that " the interval between the exposure to the source of infection and the onset of parotitis in Mumps is most commonly about three weeks, a day more or a day or two less."

It is occasionally as long as twenty-five days and more rarely as short as fourteen days. There are ordinarily about three or four days of premonitory symptoms, though these amount to little more than general malaise, with some slight fever and are generally overlooked.

In a typical case the glandular swelling probably reaches its height in about four days, and in three days later the temperature is again normal. The infectiousness in Mumps begins with the earliest symptom, and the patient is probably more or less infectious till about three weeks after the commencement of the glandular swelling.

Mumps, like Measles, is so very infectious that it has often been communicated to companions before the Sanitary Authority has had notice of the initial case. Being a disease of children and young persons, information of cases is, as a rule, mainly derived from school attendance officers. The Sanitary Authority can do little except recommend and try to obtain such isolation for the patient as is practicable at his home. Children from infected houses should be kept

from schools, and after recovery of the patient, infected things should be disinfected. It is seldom necessary to close a school on account of the prevalence of Mumps.

Puerperal Fever.

Puerperal Fever is not now regarded as an acute specific fever occurring in lying-in women only, but a puerperal septic disease caused by infectious germs directly conveyed to the patient by defiled hands, instruments, sponges, etc., or otherwise. The organisms found are similar to those found in Erysipelas and Wound Fever. Indeed, infective matters from an Erysipelas patient or a Scarlatina patient, while they may cause Erysipelas or Scarlatina, may also cause a disease not distinguishable from ordinary Puerperal Fever.

Generally, about three days after delivery is completed the first symptom (chilliness or actual rigors) is noticed. The onset of the disease may occur a day after confinement or may be delayed for five days. If no symptom manifests itself during the first week, the patient has not been affected during delivery. The fever, at first rather high, usually continues for about a fortnight, when there is a change for the better or worse. In very severe cases death may take place in a few days.

The patient, and her discharges must be held as highly infectious from the first.

What can the Health Officer do in Puerperal Fever cases? They are ordinarily notified to him, or should be, and he ought to take some steps to prevent the spread of the disease.

Hospital isolation is not practicable, nor can much be done for the patient, for a case is rarely notified till the patient is dying. The infected room and contents should be thoroughly disinfected. The midwife or nurse in attendance should also be urged to submit to disinfection, and to abstain from attendance on other cases for a short period.

Epidemic Pneumonia.

Epidemic Pneumonia is an undoubtedly infectious disease, though it has been clearly recognised as such only within recent years. After inception the disease is latent from about two to five days. The first symptoms are rigors or shivering, pain in the side or over the stomach, and fever. Sometimes the pain is quickly followed by diarrhœa and vomiting. Commonly on the second day there is Pleuro-Pneumonia on one or both sides, followed by delirium. Cases are often fatal in three or four days. The crisis may be expected in a week or ten days, but this may be followed in a few days by a relapse.

This disease is not primarily an affection of the lungs, but a fever of which Pleuro-Pneumonia is a symptom and the constitutional disturbance is usually out of all proportion to the local disease.

Debilitated persons, intemperate persons, the aged, and all living among squalid surroundings appear to be specially liable to attack and to have the disease severely.

Epidemic Pneumonia may be considered infectious from the onset of the disease till recovery from the lung disease and the patient ceasing to expectorate, say three weeks, or more.

A person exposed to infection is safe after a week's quarantine.

Had this disease been more common, or had it been more frequently recognised, it is probable it would have been included in the diseases ordinarily required to be notified; but little was known of Epidemic Pneumonia till the Middlesborough epidemic was investigated and reported on, and this was only just before the Infectious Disease (Notification) Act, 1889, was passed.

If the disease were required to be notified in any district, early cases would probably be reported and might be

removed to hospital with advantage. The infected room and clothing could then be disinfected, and any sanitary defects discovered on the premises could be remedied.

Wherever else the infection of Epidemic Pneumonia may be, it is certainly in the expectoration, and as portions of this, if allowed to dry, may be carried about as infectious dust, patients should cough or spit into a piece of rag or paper to be at once burned, or into a spitting cup or vessel containing a little disinfectant solution which can be emptied from time to time into a drain leading to a sewer, and cleansed with scalding water.

Venereal Diseases.

Under the heading of Venereal diseases, three diseases are included, namely, syphilis, chancroid, and gonorrhœa.

Syphilis is caused by an organism known as the *Spirochæta Pallida.* It is a very minute and delicate, actively motile, spirally twisted, thread-like organism. It is present in the substance of, and in the discharges from, the primary sore or chancre, and its detection under the microscope is proof positive of the existence of the disease, although its absence does not necessarily mean that the sore is not specific. These organisms may also be found in the indurated glands, in the various secondary eruptions of the disease, and sometimes in the blood of affected patients. They are generally absent in the tertiary lesions of syphilis. In congenital syphilis, these spirochætæ can be found in large numbers in the tissues.

The later manifestations of syphilis can be diagnosed by means of the Wassermann test.

Syphilis may be (1) acquired, or (2) it may be congenital. In acquired syphilis the mode of contagion is generally direct, *i.e.,* the virus is inoculated on some part of the body of a healthy person by actual contact with an infected one. As this form of the disease is usually caused

by promiscuous intercourse, the seat of inoculation is invariably the genital organs. But it may also be the lips or throat (by kissing), or the finger, as in the case of medical men getting infected by examining syphilitic patients. The virus may also be conveyed indirectly through the medium of cups, mugs, pipes, shaving brushes, closets, etc., which, having been used by an infected person, are then used by a healthy one before being sterilized. This method of contagion is more likely to occur in the secondary stage of the disease, when the patients who have a characteristic rash on their bodies, and white patches in their mouths and throats, are in the highest degree infectious. The incubation period of syphilis varies from two to six or seven weeks, and that of gonorrhœa, from one to ten days, usually three or four days.

Hereditary or congenital syphilis is due to infection of the unborn child by a diseased mother, or perhaps, by a diseased father direct without the mother being apparently infected. In most cases a child infected in this way is apparently healthy at birth, and the symptoms make their appearance in different ways at various intervals.

A Chancroid or soft sore or soft chancre is due to contagion following impure sexual intercourse. As its manifestations are only local, it is of no importance from the public health point of view.

Gonorrhœa in males is an acute infection of the urethra caused by impure sexual intercourse. The causative organism is a Gram-negative diplococcus which is present in the purulent discharge and is usually found inside the pus cells. The treatment consists of irrigations with 1 in 5,000 solution of Potassium Permanganate or Acriflavine while the condition is acute and instillation of argyrol 5 per cent. solution or weak silver nitrate solutions depending on individual needs of the case. The use of Gonoccocal Vaccines is recommended for accelerating the progress of the curative process. However local treatment is the chief mainstay and has to be carried on with patience and perseverance.

There are good grounds for believing that venereal diseases are widely prevalent in India. From statistics available in the various Bombay hospitals, it is inferred that nearly thirty per cent. of the hospital patients are infected with syphilis. In the opinion of the Royal Commission on Venereal Diseases, the number of persons in Great Britain, who have been infected with syphilis, acquired or congenital, cannot fall below ten per cent. of the whole population in the large cities. It is necessary to remember that gonorrhœa is considerably more common than syphilis, and it would then be easy to realize how strong a grip these diseases have on the population, and for how much sickness, suffering, and death they are responsible.

The evil effects of venereal diseases entail great loss both from an economic and public health points of view. Syphilis and particularly gonorrhœa, cause considerable suffering to individuals who get infected with them. For instance, in males, orchitis, prostatitis, stricture of the urethra, cystitis, pyelitis are all common if treatment is neglected. In females, inflammation of the uterus, lovaries, fallopian tubes, pelvic peritonitis, pyosalpinx, leading to acute illness or chronic invalidism, are all likely to occur. Gonorrhœal arthritis or rheumatism may occur in both sexes, and lead to more or less permanent crippling of various joints. But apart from these individual sufferings, these diseases are responsible for a large proportion of all cases of sterility in men and women, which must have an adverse effect on the birth rate. This is still further affected by the very large number of still-births due to syphilis. These still-births contribute in a great measure to an increase of infant mortality, and among the unfortunate victims of congenital syphilis who escape early death, are the very large number who, by reason of blindness, deafness, or imbecility, impose such a heavy burden on the State. Ophthalmia Neonatorum is the most serious of the effects upon the offspring of maternal gonorrhœa, and it is estimated that between 50 and 60 per

cent. of all blind children owe their blindness to it. If we bear in mind the fact that the education of the blind child is much more costly than that of the normal child, and also that the earning capacity of these affected people is greatly reduced, we shall be able to realize that their maintenance and care must entail a heavy and unremunerative expenditure of public and private funds.

Among the adult population the wastage and mortality caused by these diseases are by no means insignificant. The loss of working power in the early stages when the diseases are contracted, though large in the aggregate, is relatively small compared with the amount of invalidism, incapacity, and deaths caused by the later or tertiary manifestations of syphilis. The circulatory and nervous systems are particularly affected by syphilis, and certain common and fatal diseases are the late after-effects of its infection. Amongst these may be mentioned aortic sclerosis, leading to aneurysm, aortic regurgitation and angina pectoris due to the involvement of the coronary arteries of the heart, locomotor ataxy, optic atrophy, and general paralysis of the insane. It is estimated that the last mentioned disease accounts for about 15 per cent. of all the male admissions, and 3 per cent. of all female admissions to lunatic asylums, and as a matter of fact the Royal Commission on Venereal Diseases estimated that the treatment of Lunacy caused by syphilis involved an annual expenditure in England and Wales of about £150,000. According to Kenwood and Kerr, syphilis is also probably a predisposing cause of tuberculosis and cancer of the tongue.

PREVENTION OF VENEREAL DISEASES.

The lines along which these diseases may be attacked are :—

(1) Compulsory notification.
(2) Prompt and efficient treatment of infected persons.
(3) Education of the public in matters of sex-hygiene, etc.
(4) Control of prostitution, marriage of infected persons, etc.

One of the most important prophylactic measures against all infectious diseases is compulsory notification. In regard to venereal diseases, opinions are divided on the

advisability or utility of this measure. Notification is of little assistance unless it is supported by a system of compulsory treatment and perfect secrecy is maintained so as to encourage sufferers to come for treatment and continue it till cured. The object of treatment is both to cure the diseased persons and what is more important, from the prophylactic point of view, to render them non-infective. It is essential, therefore, that treatment on modern lines must be begun early and should be continued long after all symptoms have cleared up.

To avoid infection by sexual misconduct it would not be improper to instruct people that the risk may be greatly lessened if the parts are thoroughly cleaned immediately afterwards by careful washing with soap and water, and applying calomel ointment to the parts within reach and by an injection of 1 in 1,000 solution of Potassium Permanganate into the male urethra and female vagina as the case may be. To effect this preventive measure "Ablution Centres" have been established abroad. Such disinfection may be done by the person himself known as "Self disinfection," or secondly at the hands of a trained person, known as "Skilled disinfection."

In regard to education a wide-spread campaign has been recommended in this direction, not only as to the nature and effects of the disease, but as to the moral and spiritual considerations involved in the question of sex relations. This instruction should be undertaken either by the parents or school teachers.

In the fight against these diseases, very stringent measures against brothels, soliciting, procuring, and immoral literature, are necessary, and as a matter of fact such social regulations do exist in Bombay, and are administered by the Police with the help of the "Social Purity League" and other similar bodies.

The regulation and official toleration of professional prostitutes has been found to be medically useless as :—

(*i*) No medical man can possibly declare a prostitute free from disease by occasional examination,

either bi-weekly or weekly—when she exposes herself frequently to possible infection. (*ii*) Secondly there is a false sense of security engendered in the minds of young men by this State Regulation, and they are naturally encouraged to expose themselves to risk. (*iii*) Thirdly, a large amount of clandestine prostitution is not affected by these measures, and it is futile to put out of action some diseased women if diseased men continue to infect others.

The Local Government Board in England have issued certain regulations (Public Health—Venereal Diseases, Regulations 1916) for providing treatment and carrying on an educational campaign. All information obtained in regard to any person treated should be regarded as confidential. "The Venereal Diseases Act 1917" in England makes it illegal for any but a fully qualified Medical Practitioner to undertake the treatment of these diseases.

Opinion is gaining strength that persons in an infective state should not be allowed to marry. Such preventive legislation does exist in Sweden but it would be a matter of absolute impossibility in India.

The Social Hygiene Council are of opinion that in a place like Bombay, there is little to be gained from compulsory notification and treatment, and they offer the following three constructive suggestions for dealing with these diseases in Bombay:—

"(1) A high standard of free and adequate facilities for the diagnosis and treatment of Venereal Diseases, available to the whole population.

(2) An intensive and continuous campaign of public enlightenment.

(3) A system of voluntary treatment should be initiated and actively promoted over a period of years."

Period of Isolation of the Infected in Various Infectious Diseases—Infective Period.

Varicella (Chicken-pox).—Until every scab has fallen off, particular attention being paid to the scalp.

Diphtheria.—In no case for less than four weeks, and until convalescence is completed, and there is no longer any sore throat, or any abnormal discharge from the throat, nose, ears, or eyes, no cutaneous pustulation and no albuminuria, and at least two successive bacteriological examinations of the pharyngeal and nasal mucus for the specific bacillus have been attended with negative results; each examination having been made not less than twelve hours after the discontinuance of local antiseptic applications.

Rubeola (German Measles) and Epidemic Roseola.—For not less than ten days from the date of the appearance of the rash.

Morbilli (Measles).—Until desquamation of all the scabs and subsidence of all catarrhal conditions. Usually, not less than three weeks from the date of the appearance of the rash, convalescence being satisfactorily established.

Mumps.—For not less than three weeks from the commencement, provided that one clear week has elapsed since the complete subsidence of all swelling.

Scarlatina (Scarlet Fever).—For not less than six weeks from the date of the appearance of the rash until convalescence is completed, and there is no sore throat, discharge from the ear or nose, suppurating or recently enlarged glands, or eczematous patches. If nasal or aural discharges persist, complete isolation for 12 weeks (preferably upto 20 weeks) should be enforced.

Variola (Small-pox).—Until every scab has fallen off and the skin lesions have all healed.

Pertussis (Whooping Cough).—For not less than six weeks from the commencement of the whooping, and until the characteristic spasmodic cough and the whooping have ceased for at least two weeks.

TABLE OF INCUBATION AND QUARANTINE PERIOD IN DAYS.

	Incubation. Days.	Average. Days.	Quarantine. Days.
Varicella (Chicken-pox)	11—19	14	20
Diphtheria	few hours — 5	2	12
Rubeola (German Measles) ..	9—18	14	20
Epidemic Roseola	9—18	14	20
Morbilli (Measles)	10—14	10	18
Mumps	14—23	21	24
Scarlatina (Scarlet Fever) ..	2— 8	4	10
Variola (Small-pox)	10—14	12	16
Whooping Cough	7—19	14	21

Flies.

In the preceding pages of this chapter, reference has frequently been made to the flies as being concerned in the transmission of several diseases. An account of the life-history of the fly and the measures for its control, will not be out of place here.

The flies that enter houses and carry disease are generally of two kinds : House-flies and Blow-flies or Blue-bottles. Howard, working in the United States, accounted for no less than 77 varieties, of which 36 accomplished their larval evolution in refuse and filth. Among those which are met with in houses, some possess a great numerical predominance in inhabited surroundings. The following is a list, in order of their importance :—

(1) The house-fly (*Musca domestica*), by far the most common and representing 97 per cent. of the flies in houses.

(2) The lesser house-fly (*Fannia canicularis*), which appears sooner than the preceding one, and is distinguished by its lesser dimensions.

(3) The blue-bottle or blow-fly (*Calliphora vomitoria*), which scents meat from afar and which is so troublesome to get rid of.

(4) The green-bottle (*Lucilia cæser*) always in quest of decomposing matter, where it thrives and propagates.

(5) The striped fly (*Viviparous*), which may be seen flying in the country and depositing completely formed grubs on putrescent matter.

It is exceptional to meet inside houses the *Stomoxys calcitrans* or *Muscina stabulans*, the stable fly or biting house-fly, which harasses domestic animals in order to suck their blood.

STRUCTURE OF THE FLY.

While it is unnecessary to enter into a detailed account of the anatomy of flies, a short account of certain features is desirable.

The house-fly, the blue-bottle and the green-bottle have somewhat similar characters. All are inermous, *i.e.*, are deprived of biting organs; they have maxillary palps and a proboscis through which the fly sucks up the fluids on which it feeds.

The extremity of the leg (tarsus or foot) is covered with minute microscopical hairs, and has a pair of membraneous pads or pulvilli covered on their ventral surface with innumerable closely set hairs forming a kind of cup. By some these cups are supposed to form a sort of vacuum, by means of which the insect is able to adhere to objects on which it alights. By others, it is supposéd that the pads secrete a sticky substance by means of which the fly grips. Each leg is like a minute paint brush, which is applied to the surface of whatever it rests upon.

When this is water, the hairs do not appear to be wetted.

The essential parts of the alimentary canal are a gullet, stomach, crop, intestine and rectum. The gullet is prolonged

to a minute opening between the flaps of the proboscis, half-way down which it is joined by the salivary duct. At the entrance to the stomach it is bifurcated, and one limb of the bifurcation is extended backwards to the bi-lobed crop. By a valvular apparatus at the entrance to the stomach, the insect can direct the liquid, driven by the pump in its trunk, into either the stomach or crop. The proboscis is a highly elastic muscular organ with universal movement. At the end are two flaps or labella, which it can open out like the leaves of a book, and apply the medial surfaces to the material it feeds upon. From the middle line or hinge, minute chitinous channels pass outwards to the margin. These tubular structures are strengthened at frequent intervals by chitinous rings like a trachea, but are not complete tubes, being open to the surface by a minute linear channel with lateral bays in it. At the base of the trunk, a number of muscle fibres are attached to the gullet, by the peristaltic contraction of which fluid is pumped up from the mouth and propelled into the stomach or crop. The structural arrangement of the flaps of the trunk acts as a filter. Graham Smith is of opinion that solid objects larger than 0.006 m.m. seldom pass into the gullet. According to Nicoll, the ova of such tape-worms as do not exceed 0.035 m.m. in their smallest diameter may be swallowed. These must therefore get into the mouth direct. When feeding on a liquid, the fly applies the labella to the surface, and sucks the liquid through the "strainer" first of all into the crop. When this is full, some goes into the stomach. In the case of solid material such as sugar, dried blood or sputum, the insect must first dissolve the material. This is done by pouring saliva upon it or more generally by regurgitating some of the contents of the crop (Graham Smith).

Graham Smith by feeding experiments with coloured syrup, found that the meal was first taken into the crop, and subsequently transferred to the stomach at leisure. The fly could, however, first fill its crop and then its stomach.

In a quarter of an hour, the meal had passed on to the upper third of the intestine and in a warm incubator at 37° C., reached the rectum within an hour. The fly seems to keep some of the fluid in its crop for days.

A well-fed fly deposits fæces abundantly. Graham Smith noticed flies to do this ten times in the first hour after feeding. A curious habit of flies, to which, so far as we know, attention was first drawn by Graham Smith, is the regurgitation of the contents of their crops. This has already been referred to as a means by which they are enabled to feed upon dry material soluble in water. They do this very frequently when walking over a clean glass, possibly with the idea of extracting nourishment from it. A fly, after a good meal, may often be seen blowing fluid bubbles from its trunk and sucking them in again.

From the above account it is clear that there are a *priori* reasons for suspecting the fly of carrying bacterial infection. Born in a dunghill, it spends its days flitting between the sugar basin, milk pan, and any fæcal matter available. Its hairy, probably sticky, feet and the habit of regurgitating the contents of the crop and defæcating at frequent intervals suggest it to be an excellent inoculating agent for any bacteria it may pick up in the satisfaction of its unsavoury tastes.

That it does, indeed, operate in this way has been abundantly demonstrated. Flies which have wandered over cultures of organisms, and afterwards been allowed to walk upon sterile agar plates, leave a rich crop of germs as their footprints, which can be demonstrated by subsequent incubation. Castellani transferred Yaws to monkeys in an analogous way.

The conveyance of infection by the alimentary canal and its deposition by regurgitation or fæces has been conclusively proved.

These modes are probably more important than the carriage of bacteria upon the exterior. Many pathogenic

bacteria would soon die from desiccation on the appendages of the insect and, at any rate, the number so conveyed is small compared to those contained in its crop and intestine.

Carriage within is certainly more lasting, for Graham Smith to whom we are indebted for the most thorough investigation of this subject, isolated Typhoid and other bacilli from the intestinal contents of flies six days after feeding on material containing the organism under test. The fæces ceased to afford growths after two days when Typhoid bacilli were the infecting organism used, but with a more robust organism, such as Anthrax, which can protect itself from the effects of drying, the time was much longer.

The table below taken from Dr. Graham Smith's report, summarizes the result of his experiments on the length of time after which various bacilli can be recovered from the outside and inside of flies fed on infected material. As the author is careful to point out, in these experiments gross infection was produced by feeding upon pure cultures, and they do not do more than indicate the duration of life of various pathogenic bacteria under favourable conditions.

TABLE SHOWING THE LONGEST PERIOD AFTER WHICH ORGANISMS WERE RECOVERED FROM FLIES FED ON CULTURES (GRAHAM SMITH).

Organism.	Legs.	Wings.	Head.	Crop.	Gut.	Fæces.
B. typhosus	..	..	..	..	6 days.	2 days.
B. enteritidis	7 days.	..	7 days.	8 days.	7 days.	..
B. tuberculosis (culture) ..	..	..	..	3 days.	16 days.	13 days.
B. tuberculosis (sputum) ..	..	..	..	..	7 days.	5 days.
Yeast	2½ hrs.	2½ hrs.	2½ hrs.	2 days.	3 days.	2 days.
B. diphtheriæ	5 hrs.	5 hrs.	5 days.	7 days.	5 days.	2 days.
B. anthracis (no spores) ..	2 days.	..	4 days.	5 days.	3 days.	2 days.
B. Choleræ	30 hrs.	5 hrs.	5 hrs.	2 days.	2 days.	30 hrs.
B. prodigiosus	8 days.	12 hrs.	11 days.	5 days.	17 days.	6 days.
Anthrax spores	20 days.	20 days.	20 days.	13 days.	20 days.	13 days.

Cao, Bacot, Ledingham and Graham Smith have further shown that in the case of larvæ fed on material infected with various organisms, B. pyocyaneus, B. typhosus, and B. anthracis respectively, the infection may be carried through the chrysalis stage and recovered from the contents of the intestine of the fly after its emergence. Fortunately, however, according to Ledingham, B. typhosus leads a precarious existence in competition with the natural bacterial flora of the larvæ and pupæ.

There are numerous recorded instances, in which the pathogenic organisms of Cholera, Typhoid, Phthisis, Anthrax and Plague have been recovered from the interior or dejections of flies which have been captured in the immediate neighbourhood of cases of the disease or, in the last two cases, of carcasses of animals dead of the disease. The spread of Ophthalmia in hot countries has, on good grounds, been attributed to the agency of flies in carrying the Koch-Weeks bacillus and the gonococcus from eye to eye. The seasonal and local prevalence of Ophthalmia corresponds with that of flies.

HABITS OF THE FLY.

All these insects have the same habits and especially the same craving for decaying matter. The house-fly, which particularly interests us, seeks the environment of man, lives in his surroundings, passes alternately from the interior to the exterior of habitations, always in search for food, sometimes flying to a distance of several hundred yards. It is precisely in man's surroundings it finds most easily pathogenic material to transport; hence the danger arises. During its wanderings, the insect stops at all kinds of substances which attract it, plundering successively filth, manure, house refuse, street sweepings, mud from streams, &c., then it alights on our food on street stalls and in markets or in the interior of houses which it contaminates. It is easy to imagine what may result from this continual going and

coming of these dirty insects. Fresh and moist defectations attract them much more than old and dry ones; their avidity is even greater for the segments of flat worms which they may find there. The females are particularly attracted by putrefactive odours, which indicate to them the favourable places for breeding. To lay their eggs, the flies seek organic substances in decomposition, so that the larvæ will be assured of nourishment. The house-fly is very fond of dung especially horse dung, stables and badly kept yards, and does not ignore the privies, middens, refuse heaps, kitchen waste and in a general way, everything that can putrefy. Its eggs have even been found in fermenting straw, old papers and rags, and even in accumulated dust in the cracks of window frames.

LIFE HISTORY OF THE FLY.

The fly undergoes a complete metamorphosis, in which there are four well marked stages. These are—

(1) the egg, commonly known as fly-blows,

(2) the larval or maggot stage,

(3) the pupa or chrysalis stage, and

(4) the nympha terminating in the imago or perfect fly.

1*st Stage*.—The eggs are laid in small irregular clusters or in large collective masses, consisting of many thousands of individual eggs. They are almost invariably deposited on or in such substances as will provide food for the larvæ or maggots. They are usually placed in narrow crevices near the surface, but occasionally also at a distance of from 4 to 6 inches below the surface, the favoured spots in all cases being *fermenting vegetable matter* or the refuse lying immediately over such materials, or the refuse that is likely to ferment. They may however be laid, on materials which do not ferment, and in all such cases the developmental cycle is greatly prolonged.

The number of eggs laid by a single fly at a time averages from 100 to 120 disposed in a heap, or even 3 or 4 similar heaps.

The eggs are sausage-shaped with one end sharp, glistening white in colour, and about 1.5 to 2 m.m. long by ·3 to ·5 m.m. broad in their greatest diameters. The hatching of the egg into a larva or maggot depends on the temperature and the time of the year. In very favourable circumstances, it may occur in 8 hours, more often in 24, and it may extend to 3 or 4 days. The larva is an active little grub 2 m.m. long with a sharp anterior and a blunt posterior end. In appearance it is composed of a series of rings, legless and creamy white in colour. It is essentially a vegetable feeder; animal matter is eaten only when in the form of human fæces or animal excreta. It has never been found feeding on the carcasses of dead cats and dogs, or of birds and fish remains.

2nd Stage.—The larvæ thrive and mature most rapidly, and are always most abundant in *fermenting* materials; but they can also mature in non-fermenting substances during warm weather, though very slowly.

In stable manure they are generally most numerous a few inches below the surface, and they work their way upwards day by day into fresh material a few hours (5 to 6) after it has been added to the previous accumulation. This marked habit is evidently due to the excessive heat which is engendered in the lower strata of the manure. The growth of the larvæ depends on conditions of nutrition and the temperature: it is usually rapid and completed in 4 to 5 days but under unfavourable circumstances, it may extend over several weeks (upto 6 or 8). In due time the larva hardens, becomes shorter and is transformed into a pupa. At the time of pupation, the grub is 6 to 9 m.m.

3rd Stage.—The *pupa or chrysalis* is at first of a pale yellowish colour, but rapidly changes to bright-red and finally

to a dark chestnut colour. It is somewhat barrel-shaped and varies in length from $\frac{2}{12}$ to $\frac{3}{12}$ of an inch. Small examples are found where the temperature has been low or excessively hot and somewhat dry. Large examples invariably occur in fermented materials, more especially so in stable manure.

In stable middens, the pupæ occur chiefly at the sides or at the top of the wall or framework of the receptacle where the temperature is lowest. In such situations they are often found packed together in large masses numbering many hundreds. The flies emerge from the pupæ, under the most favourable conditions, in five to seven days. In all cases where heat is not produced by fermentation, the pupal stage may last from 14 to 28 days, or even considerably more.

4th Stage.—It is under the membrane of this pupa that the nymphal stage takes place, lasting under the most favourable circumstances from 3 to 7 days according to the temperature and this gives birth to the mature fly or imago.

The perfect fly escapes from the pupa by breaking away the anterior end; this it accomplishes by inflating the frontal sac, which is situated between the eyes. By the inflation of this sac, the fly is also enabled to force its way through the manure or ashes into the open air. When once it has liberated itself, the wings develop and, when the integument has sufficiently hardened, the fly takes to wing. Pairing takes place in due time, eggs are laid and another generation is started. The whole cycle from egg to perfect insect occupies, under the most favourable conditions, from 10 to 14 days, but in low temperatures, the whole cycle may extend to several weeks.

The sexual maturity is precocious in the house-fly. According to Hewitt, they become sexually mature in ten to fourteen days after emergence from the pupal state; and four days after mating, they are able to deposit eggs. Griffith has even seen females lay eggs ten days after hatching out.

Howard thinks that these figures, taken from experimental breeding, are a little exaggerated and that, in the conditions of free life and abundant nourishment, the laying should commence earlier. Whatever it may be, admitting a margin of fifteen days for the complete development of the insect, from the egg upto the imago (the evolution is often quicker), one can see that during the six months of the favourable season, a single fly can lay seven different batches and produce seven successive generations. As the number of eggs laid by each female is about 120, it follows that from the beginning of summer to the first touches of autumn cold a single fly can produce millions of individuals. Calculating all the chances, one obtains stupefying figures. According to Howard, a single fly commencing to lay about April 15, in the climatic conditions of Washington, could from this date up to the end of September, and by the ulterior proliferation of the individuals of each successive generation, produce 5,598,720,000,000 flies. Considering this gigantic fecundity, it is easy to understand the extraordinary increase of these diptera in favourable conditions.

LENGTH OF LIFE.

The length of life of flies has not been definitely established; it appears to be from six weeks to nearly four months during the summer. The house-fly is common in houses from June to September, is scarce in October, and is very rare as soon as the first cold of winter approaches. The fall of temperature suffices to kill off a very large number; many succumb to an infection by a parasitic fungus, Empusa muscæ, which is prevalent amongst insects particularly at the beginning of autumn. It has been too easily believed that all the adult flies perish in winter: if this were a fact, it disagrees with the perpetuity of the species. The researches of Jepson on the breeding of flies in winter at laboratory temperature (18° C. to 24° C.) have resulted in some interesting observations on this subject. Contrary to public opinion, he says that flies do not all disappear in winter, but know

where to find places and conditions of temperature suitable for their prolonged existence. Those that are caught in winter have a greater resistance and longevity than those caught in summer and appear to be better adapted to surviving. Flies mate in winter also; they can therefore reproduce in this season, if nothing interferes with the evolution of their larvæ in their resting-places. These facts are in agreement with current observations. Assuredly, the first frosts kill the majority of the diptera exposed to the cold, as well as their eggs, larvæ and pupæ. But a certain number continue to live, fly and mate in heated or naturally warm places. Others hibernate, benumbed, in certain protected places, and await the hour of revival for the reproduction of the species. Galli Valerio has observed in his laboratory, in the middle of winter, generations of flies emerge from eggs laid in dust in cracks of window frames; reproduction can therefore take place in winter. This question of hibernation of flies of which we only possess imperfect knowledge, is highly important from a practical point of view. It deserves to be studied for obtaining precise knowledge as to the conditions of living, surroundings, temperature, &c., which are favourable to the life of these diptera and their indefinite preservation. As Jepson rightly says, if the winter flies are only found in certain warm places and as isolated colonies, we may hope to reduce their number appreciably and perhaps exterminate them.

NUISANCE FROM FLIES.

The system of refuse removal in the City of Bombay aims at preventing a single dust-bin remaining unattended to in the course of the day. But the most important point is that no refuse, etc., should remain clinging on the side and crevices of these carts, as such places may afford a nidus for the flies to deposit their eggs. For this reason it is absolutely necessary that all carts should be washed at least once in every seven days. There is a standing order of the Health Department to this effect.

As regards human excreta, there is no doubt that basket privies provide breeding and feeding ground for flies. In order to minimise this nuisance, the system of removal twice a day has been introduced so as to prevent accumulation. The most serious nuisance that is observed everywhere is the practice of allowing young children to defæcate in public streets, alleys and passages. In all the Presidency Magistrates' Courts this offence is considered punishable under section 372 of the City of Bombay Municipal Act. This filthy habit must be checked by repeated prosecution of the parents.

There now only remains the question of stable-refuse accumulating in licensed and unlicensed stables. Such heaps of refuse, especially in the monsoon, afford suitable breeding places for these flies. It is therefore very necessary to enforce the sections of the Act bearing on the subject, especially section 372. It is also desirable to treat such heaps every three days with a solution of pesterine, as it is a known insecticide.

Flies have a *persistent habit of feeding or alighting upon human excreta* and thus they play a very important part in the transmission of certain infectious diseases.

Professor Robert Newstead of the Liverpool School of Tropical Medicine carried out a long series of systematic investigations on this subject; he observed flies sitting on deposits of human excreta in the courts and passages of Liverpool houses and the same thing is observed in houses in India.

CONTROL OF DOMESTIC FLY.

Mr. Newstead summarises his conclusions as follows :—

i. The chief breeding places of the house-fly are—

  (*a*) Stable middens containing fermenting horse-manure or a mixture of this and cow-dung.

  (*b*) Ash-pits containing fermenting vegetable matter in about 25 per cent. of the total number of pits examined.

ii. Covered ash-pits and middens were as badly infected as those which were open.

iii. House-flies breed in all temporary collections of fermenting matters.

iv. House-flies breed in relatively small numbers in ash-pits where no fermentation takes place.

v. They do not breed in ash-pits which are *emptied at short intervals*, or in the patent bins.

vi. The use of disinfectants in ash-pits does not prevent the flies breeding in such receptacles.

vii. Very dry or excessively wet ashes and moist cow-dung do not harbour them. (In exclusively hot summers cow-dung may form a breeding place for the house-fly. The admixture of a large quantity of bedding (straw or saw-dust) would also render it suitable for breeding purposes.)

viii. The presence of fowls (not ducks or geese), which had free access to the stable middens, reduced the number of larvæ and pupæ to a very marked extent.

ix. The life-cycle of the fly in all kinds of fermenting materials is reduced to the minimum period of 10 to 14 days; and in the absence of such artificial heat, the cycle may occupy a period of from 3 to 5 weeks or more, according to the temperature of the outside air.

x. House-flies do not depend entirely upon excessively warm weather for breeding purposes, though in hot seasons they would breed much more rapidly in non-fermenting materials, and their numbers, under such conditions, would be greatly increased.

Mr. Newstead further makes the following suggestions to reduce house-flies to a minimum :—

(1) Stable manure should not be allowed to accumulate in the midden steads for a period of more than seven days.

(2) All midden steads should be thoroughly emptied and carefully swept. The system of *partly emptying* such receptacles should in all cases be discontinued. The walls of midden steads should also be cemented over; or failing this, the brick work should be sound and well-pointed.

(3) All ash-pits should be emptied during the summer months at intervals of not more than ten days.

(4) The most strenuous efforts should be made to prevent children defæcating in courts and passages; or the parents should be compelled to remove such matter immediately; and defæcation in stable middens should be strictly forbidden. The danger lies in the overwhelming attraction which such fæcal matter has for house-flies, which latter may afterwards come into direct contact with man or his food stuffs. They may, as Dr. Veeder puts it, "in a very few minutes......load themselves with dejections from a Typhoid or Dysentric patient, not as yet sick enough to be in hospital or under observation, and carry the

poison so taken up into the very midst of food and water ready for use at the next meal. There is no long round-about process involved."

(5) Ash-pits refuse, which in any way tends to fermentation, such as bedding, straw, old rags, paper, waste vegetables, dirty bedding from the "hutches" of pet animals, etc., should, if possible, be disposed of by the tenants preferably by incineration, or be placed in a separate receptacle so that no fermentation could take place. Pesterine—crude petroleum—kills larvæ and eggs and prevents the breeding of flies.

(6) The application of Paris Green (containing arsenic, copper and acetic acid) at the rate of 2 ozs. to one gallon of water to either stable manure or ash-pit refuse will destroy 99 per cent. of the larvæ.

One per cent. of crude atoxyl in water is deadly to fly larvæ. (Care should be taken that cattle do not eat the straw treated with this poison.)

(7) The use of sun-blinds in all shops containing food which attract flies would largely reduce the number of flies in such places during the hot weather.

(8) The screening of midden steads with fine wire gauze would, undoubtedly, prevent flies from gaining access to manure, etc., but it is very doubtful if this method would meet with any marked success. The gauze would rapidly oxidise, the framework supporting it would probably warp and a number of flies would be admitted whenever the receptacle was opened.

MR. H. MAXWELL LEFROY STATES.—To keep flies out of houses, to lessen their numbers and to prevent the dissemination of disease by their agency, some or all of the following methods will prove useful and may be found practicable :—

Stable or farm yard manure should be dried, or dug into the ground ; it should not be allowed to rot in a heap in the open. If this is not possible, periodical sprinkling with borax or crude mineral oil may keep flies from laying eggs upon it or kill any eggs that may be deposited. If the dung heap can be spread out and dried every few days, the breeding of flies will be prevented. "*Flies cannot breed* in dry surroundings."

Borax has not been found suitable under all circumstances, but Newstead finds that watering manure with borax solution hinders the pupation of the maggots. After exhaustive trials in England, the following method has been found best: a crude tar or creosote oil, such as green tar oil or neutral blast furnace oil is mixed at the rate of 1 gallon to 40 gallons of

earth or sand and the mixture spread over the manure heap one inch deep, *i.e.*, 40 gallons mixture to 80 square feet of surface. Manure so treated is immune from fly-breeding and if already infected is rendered unsuitable to the further development of the maggots. If it is a question of dealing with manure containing no straw or litter, the oil alone may be used watered on very lightly, *i.e.*, 1 gallon to 80 to 100 square feet of surface. Crude mineral oil does not give such good results.

Where any form of crude tar or creosote oil is available, the method is cheap and simple.

Where space is available, simply spreading manure out on the soil in a layer four to six inches deep prevents fly-breeding except in warm, wet weather.

At large cavalry and remount depots, the accumulation of stable manure has been so large and continual, that special methods have had to be devised. *On the manure stacks*, spots where flies congregate are marked with sticks and at evening the manure at these spots is taken out and burnt or treated, as it contains immense accumulations of eggs. Tins filled with dry chaffs and with slits cut in the sides are sunk flush in the manure at selected spots and immense quantities of maggots go into these to pupate; the maggots that collect at the lower edges of the stack to pupate are destroyed by watering with creosol-soap solution or other insecticides.

These are special methods which have to be devised to meet local needs and to utilise materials that may be locally available.

"A manure heap can be used as a fly-trap if kept slightly moist and encircled to a distance of about twelve inches by a ring of straw," etc., *i.e.*, great quantities of pupæ will be got at the lower edges if a suitable dry material is provided there.

The brown chrysalides must be swept up with the straw and burnt every four days to prevent the oldest emerging as flies.

In America the official directions for the use of borax are as follows :—

"Apply 0.62 pound (approximately ten ounces) of borax to every ten cubic feet (eight bushels) of manure immediately on its removal from the stable. Apply the borax particularly around the outer edges of a pile with a flour sifter or any fine sieve, and sprinkle from 2 to 3 (say $2\frac{1}{2}$ British) gallons of water over the borax-treated manure in such a way as to thoroughly dissolve the powder.

"The reason for applying borax to the manure immediately after its removal from the stable is that the flies lay their eggs on the fresh manure, and the borax, when it comes in contact with the eggs, prevents their hatching. As the maggots congregate at the outer edges of the pile, most of the borax should be applied there." Cost per horse per day, about $\frac{1}{4}$ anna.

Outside the house, flies can be much reduced by sprinkling poisonous fluids on walls, trees and roofs, and other suitable

places where flies gather ; such fluids are also useful on manure heaps to poison the flies which come to lay eggs.

The liquids should be syringed or sprinkled in large drops out of the reach of children or domestic animals ; if sprinkling cannot be done, bunches of grass may be dipped in the fluid and hung up out of reach.

Suitable fluids are mixtures of treacle or brown sugar with water, to which is added a little sodium or potassium arsenite.

(Formula :—Treacle 10 lbs., arsenite of soda or potash 2 lbs., water 10 gallons; or treacle 1 lb., honey 1 lb., arsenite of soda or potash ½ lb., water 10 gallons.)

Where house-flies are abundant in a house or hospital ward, a solution of formalin containing milk should be placed about the room in saucers containing a piece of bread, or strips of cloth, wetted with the liquid, should be similarly distributed (Lefroy). Formula—Formalin ½ ounce, milk 1 pint, water one pint.

In France, the wires removed from baled hay are employed as fly-catchers by dipping them in the sticky liquid made of resin and oil and hanging them up : when they are coated with flies, the wires are removed and wiped, re-dipped and replaced. A suspended wire or string is usually more attractive to flies as a resting place than any other object (Lefroy).

Formula.—Resin 2 parts, linseed oil one part, boiled till the mixture becomes sticky.

A very simple fly trap can be made with a wide mouthed glass jar by placing in the mouth a funnel made of tin, wire gauze or of paper folded like filter-paper with a hole at the apex. A bait must be placed in the jar, when flies will enter through the funnel and be unable to escape: a good bait is a banana, some jam or some cornflour, or similar pudding or custard.

CHAPTER IX.

Malaria and Mosquitoes.

Malaria is a parasitic disease caused by a plasmodium belonging to the class of sporozoa. The disease is conveyed from man to man by a mosquito of the anopheline species. It is largely prevalent in the tropical and sub-tropical countries.

Symptoms.—The fever is characterised by three stages—cold, hot and sweating. In the first stage there are peculiar chilly sensations with pains in various parts of the body. The chilly sensation increases rapidly and the patient begins to shiver and is compelled to go to bed. He feels intensely cold and piles over himself a heap of bed-clothes. This stage usually lasts from a few minutes to half an hour or it may be longer.

The hot stage may set in gradually or suddenly. As the temperature goes up the shivering lessens. The blankets or heavy clothes are thrown off. The patient has severe headache and there is often vomiting. The temperature varies from 102.5 to 105°F. or higher. This stage lasts a varying length of time according to the type of the infecting parasite.

In the sweating stage sweat appears on the forehead, chest and hands followed by a drenching perspiration. The temperature falls to normal and the patient feels comparatively free from discomfort. This stage lasts from two to four hours.

After this the patient feels well and is able to attend to his normal avocations without much discomfort. The attacks of fever recur at definite intervals corresponding to the length of time which the infecting parasite takes to sporulate which may be 24, 48, or 72 hours.

After a few attacks, with proper treatment, the fever disappears. Sooner or later the person may again suffer from attacks of fever if he is indisposed or catches chill or if his general vitality is lowered from some cause.

In chronic cases of malaria the spleen and liver are enlarged and the person becomes very anæmic due to the continuous destruction of blood cells by the parasites. In children living in malarious districts and who have suffered from the disease the enlargement of the spleen is very marked.

Malarial fever does not commonly kill directly. The mortality is only 1 to 2 per cent. Repeated attacks by lowering resistance predispose the sufferers to other diseases. The disability due to malaria is so great that frequent attacks interfering with the regular work of labourers and others cause considerable economic loss.

Diagnosis.—The clinical manifestations of malaria are so varied that they may simulate any other disease. Malaria cannot be diagnosed from fever alone. Clinical symptoms and the temperature chart are suggestive of malaria but not diagnostic. Presence of parasites in the blood is the only true test of diagnosing malaria.

Historical.—A few facts relating to the discovery of the cause of malaria which are of historical interest may be mentioned.

Before the discovery of the cause of malaria the disease prevailed largely in Italy, particularly in the vicinity of marshy lands in the southern parts of the country. At first it was believed that the fever was caused by damp air emanating from marshy swamps in the neighbourhood of their dwellings. "Malaria", the name of the fever, is originated from this belief of the Italians as in their language "Mal" means "bad" and "aria" means "air." They were not very far from the truth in stating that they suffered from this peculiar type of fever on account of their living in the vicinity of marshes but they entirely lost sight of the chief factor which had its origin in the water-logged lands and was largely contributing to the spread of the disease.

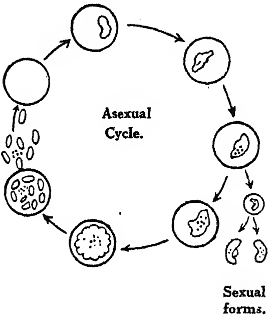
In 1898 Ross working in India demonstrated that a certain species of mosquitoes transmitted the disease from man to man through their bites. He showed that if a particular type of mosquito be fed on the blood of birds infected with plasmodium it enters the stomach wall of the insect where it grows and sporulates. The resulting sporozites enter the salivary glands of the insect which is then capable of infecting other birds by its bite. Thus by direct observation and analogy Ross proved distinctly that the extra corporeal phase of the malaria parasite was passed in particular species of mosquitoes and that the parasite was transferred from man to man by the mosquitoes.

Malaria parasite.—The malaria parasite is a protozoon lowest in the scale of animal life and consists of one cell only. It is a parasite living and growing at the expense of other animals which are called its hosts. During the process of development and multiplication it produces a variety of chemical substances. This parasite multiplies both sexually and asexually, the asexual process is carried out in man, its primary host and the sexual process in mosquito, the intermediary host.

Development of the parasite in the human body.—Shortly after an infected mosquito has bitten an individual the parasites introduced in the blood stream enter the blood cells. Some of the parasites are destroyed by the white blood cells, while others attacking the red blood cells feed and sustain themselves on the protoplasmic substance of the cells. The parasite grows and develops inside the cell by amæboid movements. At each such movement it consumes more and more of the protoplasm of the blood cell and at the same time grows bigger in size until it occupies the whole cell. It then divides and sporulates. The blood cell eventually bursts and liberates the spores into the blood stream. Each young parasite then commences a new cycle of life in another blood cell and in its turn is responsible for additional parasites thrown into

the blood stream. This method of propagation may be continued indefinitely. Thus a single bite of an infected mosquito may be responsible for millions of parasites in the blood.

In the process of sporulation the malaria parasite divides into from 8 to as many as 24 or 32 spores according to its kind. This process of division and multiplication which takes place in the human body is known as the asexual cycle.



Different kinds of parasites.—There are at least three kinds of malaria parasites each of which produces a different type of fever. These are classified according to the length of period intervening between two attacks and are known as (1) Benign tertian, (2) Quartan and (3) Malignant tertian. The parasites causing these types of fever are known as (1) Plasmodium vivax, (2) Plasmodium malariae and (3) Plasmodium falciparum.

In the Benign tertian type of fever the parasites require about 48 hours or two days to divide into daughter cells from the time of their entering the red blood cells. When it requires nearly 72 hours or three days for the parasites to develop fully and multiply, the fever is known as Quartan. In the

third variety known as Malignant tertian the parasite divides into daughter parasites in about 24 to 48 hours. In this last form the periodicity of attacks is much irregular than in the other two and it also produces the most serious and complicated kinds of malarial fever.

Each life cycle of a parasite therefore covers a period of two to three days and the rise of body temperature synchronises to some extent with the shedding of each successive crop of young parasites in the blood circulation.

After an untreated attack has run its course, the fever subsides and no parasites are seen in the blood, but two forms of the parasite still remain in the body, *i.e.*, (*a*) latent or resting forms probably in the liver and spleen and (*b*) specialised sexual forms in the general circulation.

(*a*) The latent or the resting forms retire from the general circulation after the attack ~~and remain~~ inactive in the deeper organs of the body, until perhaps the treatment is relaxed too soon, or till such time as the resistance of an individual is lessened by chill, exposure to sun, exhaustion or other causes when they may return to the circulation and become active by entering the blood cells, producing a relapse. The relapse has most of the features of the primary attack with all its train of symptoms and ill-effects.

(*b*) The sexual forms which are not fever producing parasites appear in the blood during or soon after an attack has run its course. These are of two kinds and are known as male and female gametocytes. In the Malignant tertian type of fever the gametocytes assume crescentic forms and are therefore known as crescents. These specialised sexual forms of malaria parasite seem to have been provided by nature for the express purpose of propagating the species. The gametocytes leave the human body through the bite of an anopheline mosquito whilst she sucks the blood of a person harbouring the parasites.

Life of the parasite outside the human body or the sexual cycle in the mosquito.—The mosquito in whose body the parasite passes its extracorporeal life or the sexual cycle of its development belongs to the species Anopheles. Only the sexual forms of the parasite are capable of developing in and infecting the mosquito. In the blood sucked by a mosquito unless there are both the male and female gametocytes the mosquito cannot become infected. The blood sucked by the mosquito enters its stomach where the gametocytes undergo a change. The male gametocyte becomes active and produces thread-like growths from its body known as flagellæ. The flagellæ then become detached from the body and remain moving about until they come across female gametocytes and enter their bodies. A female parasite thus becomes fertilised and the sexual cycle for the development of the parasite begins in the body of the mosquito. The fertilised gametocyte becomes a very active moving body and is called a travelling vermicule or öokinet. It then enters the stomach wall and develops into a cyst. About 36 hours after the mosquito has fed on blood the parasite may be detected as a minute oval or spherical body in the stomach wall of the mosquito.

During the next few days the parasite increases in size rapidly, acquires a well defined capsule and protrudes on the surface of the mosquito's stomach like a wart. In this condition it is spherical in shape and is known as "öocyst." During this stage of development important changes take place in the interior of the parasite. Its nucleus and protoplasm divide into a number of spherular daughter cells around which slender spindle shaped nucleated bodies attached by one end all round the spherular daughter cells are ultimately formed. At a later stage the spherules disappear, leaving the spindles loose in the capsule which is packed almost to a bursting point. These spindles are known as "sporozoites." In about a week the capsule ruptures and collapses, discharging its contents, the spindle shaped bodies into the body cavity of the mosquito.

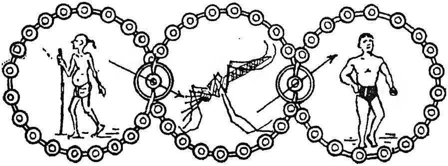
From the body cavity of the mosquito the sporozoites pass probably through the blood to the three lobed salivary glands lying one on each side of the fore part of the thorax of the insect. These glands communicate with the base of the mosquito's proboscis by means of a long duct. The sporozoites can be readily recognised in many though not in all the gland cells. They are more especially seen in the middle lobe of the gland. They are also seen in the contents of the ducts. It is at this stage that the mosquito becomes fully infective.

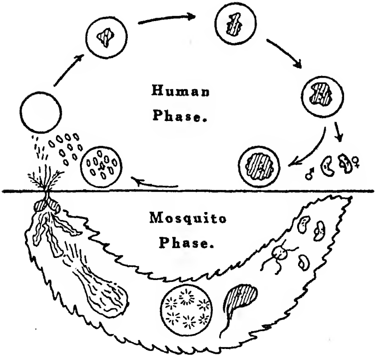
Mode of infection.—There are only a few of the Anopheles species which can be infected with the malaria parasite and in turn infect the human beings whilst feeding on their blood. By studying the mode of infection of the mosquito with the parasite it has been clearly seen that the mosquito is not born with the malaria parasites but to get them it must first bite a person who has them in his blood. Man contracts the disease through the bite of a mosquito which has been infected as described above. This proof absolutely excludes air, water and food as being the media for the transmission of malaria.

The sexual process by which the parasite multiplies in the body of the mosquito requires 12 days for its completion. It is after this period that a mosquito becomes infective. When a mosquito bites she penetrates the sucking tube or proboscis under the skin. Simultaneously with the act of piercing she injects some salivary secretion through her proboscis into the human body. Through the medium of this fluid a large quantity of the sporozoites contained in the lobes of the salivary glands are introduced in the human circulation. These sporozoites attack the red blood cells, grow at their expense, develop and multiply in an asexual manner which has already been described. It is thus that a malaria parasite propagates and multiplies by an asexual method in one host and by a sexual method in another. It may be noted that only the female mosquito can bite and suck blood, the male cannot do so and therefore the malaria parasite multiplies in only the female mosquito.

Mosquito malaria theory.—There are two fundamental principles which must first be understood and accepted as upon them are based the measures to be adopted, for the prevention of malaria. First, malaria is contracted only through the bite of a particular mosquito and secondly, man infects the mosquito and the mosquito in turn infects the man. The chain of life of the malaria parasite is therefore :—

Man ....to..... ...Mosquito.......... ....to..........Man.





It is evident that for the prevention of malaria this chain must be broken somewhere. It may be done either by (1) avoiding the bite of a mosquito or by (2) eradicating the disease from human beings who are acting as reservoirs of the parasites, by a prolonged course of treatment with quinine and the recently discovered drug plasmoquine in a systematic way. It is not however an easy proposition to try to eradicate malaria by resorting to treatment of human reservoirs although it may help in controlling the disease to some extent. Anti-malarial measures must therefore be directed against the other host, *i.e.*, the mosquito.

The complete extirpation of all the mosquitoes is an immensely difficult problem. But malaria can be successfully controlled by reducing the malaria-carrying anopheles species. For a successful anti-mosquito campaign it is essential to study the natural history of this insect. As it is difficult to attack a mosquito in its adult stage when it is on its wings, a study of its life history is necessary to find out the stage at which it can be most easily and effectively attacked.

Facts about mosquitoes.—Mosquitoes are small two winged insects and are therefore included in the zoological order, Diptera and the family of insects known as the Culicidæ.

The family Culicidæ is divided into three sub-families :—(1) the Dixinæ, (2) the Corethrinæ, and (3) the Culicinæ. The first two of these sub-families include small mosquito-like insects, which however are not armed with long proboscidæ. They are consequently not blood sucking insects and are of no importance from the public health point of view. The third family, the Culicinæ, includes similar small insects but all are armed with a long proboscis. The length of the proboscis of these insects approximately equals the combined length of the head and thorax.

Mosquitoes are included in this sub-family. A true mosquito has a long proboscis projecting in front of the head. It has a characteristic venation of the wing and there is a fringe

of scales along the posterior margin of the wings. There are also scales on the veins of wings which form the different kinds of spotting of wings. The male and the female can be distinguished from their antennæ. The antennæ of a male have long profuse hairs all along its length whereas those of a female have got few short hairs. By an examination of the external genetalia the sex of a mosquito can be easily made out. In the male the genetalia consist of two hook-like processes projecting from the last abdominal segment, which are known as claspers. At the termination of the abdomen the female has two lobes called cerci.

The tribes of Culicidæ.—The family of Culicidae or gnats as they are ordinarily known, is divided into many sub-families, genera, species and varieties and contain some five or six hundred known species. In the tropics, as a broad general rule, the mosquitoes which most concern human beings belong to the group called Culex, Aëdes and Anopheles.

Culex pipiens is a very common mosquito and allied species are found almost everywhere in the tropics. The parasite which causes Elephantiasis, the Filaria Bancrofti, is carried by them or allied species in similar manner to that in which the Anopheles carry the malaria parasite. Dengue fever is also supposed to be conveyed by this mosquito.

Aëdes egypti and allied species are very common in the tropics, but much less so in the temperate climates. In America and Africa this species is responsible for carrying the virus of Yellow fever.

The Anopheles are of about one hundred and twenty species, some of which carry malaria and are always found in malarious places.

Life History of Mosquito.

There are certain differences in the morphology of the life phases of these two tribes, *i.e.*, the Culicinæ and the Anophelinæ. For those engaged in anti-malarial work a thorough study of the life history of these two commonly found tribes

is absolutely necessary. This is of great importance as such knowledge will enable one to direct all anti-malarial measures towards the eradication of mosquitoes of the Anopheles tribe which play the principal part in the spread of the disease.

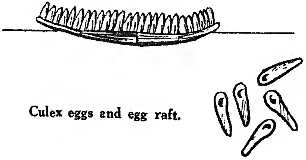
Mosquitoes lay their eggs upon water and the larval and pupal stages are also passed in the water. Their life is divided into four stages—egg, the larva (or caterpillar), the pupa (or chrysallis) and the imago (or adult winged insect).

CULEX.

The culex lays her eggs principally in tubs, barrels, cisterns, and other collections of water, more particularly in stagnant ditches, garden pits, holes in rocks and trees. She has no predilection for any particular kind of water as some of the other species have, as she is found very often laying her eggs largely even on dirty waters such as in cesspools and drains.

EGGS.

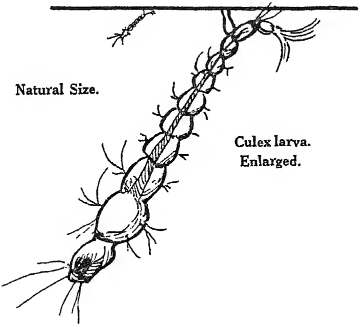
The eggs are minute objects ranging from 1 mm. to 4 mm. in length. They are deposited separately but the female arranges them in the act of laying into adherent masses which float on the water surface like tiny rafts. In warm moist weather the eggs hatch out in a day or two and the larva emerges out of the egg.



Culex eggs and egg raft.

Larva.

The next stage in the life history of a mosquito is the larval stage. The larva is entirely aquatic and always lives in water. It swims and dives by means of puddles and hairs and feeds on various aquatic organisms. It cannot, however, breathe under the surface of water and therefore always rises to the surface of water in order to breathe air. When it is in search of food it looks like a small wriggling worm. This stage lasts for a week or more, but the duration of this stage varies according to the atmospheric conditions. In cold countries the larvae may remain unchanged for a longer period than in the tropics.



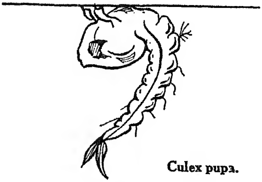
Morphology of the Larva.

The larva consists of three main parts, head, thorax and abdomen. Head carries all the mouth parts and a pair of antennæ. There are many feathered and simple hairs attached to the thorax and the variations in these appendages help in distinguishing larvæ of different species.

The abdomen is a small tubular structure attached to the thorax. It consists of nine segments. On the eighth segment in the case of the Culex there is a small tube protruding at an angle from its main body. The breathing tubes pass through the abdomen and open on the eighth segment through the projecting tube mentioned above. The larva breathes air through this syphon tube and therefore remains hanging below the water surface at an angle or hangs nearly perpendicularly. This peculiar position which a Culex larva assumes whilst floating in water is its distinguishing feature from the Anopheles species.

PUPA.

Next is the pupal stage. In this stage the larva of the former stage turns into a comma-shaped body which is known as the pupa. The pupa floats on the water surface and remains very inactive. It does not even feed itself on anything during this stage. This dormant stage lasts nearly forty-eight hours or a little longer, and the imago or adult mosquito emerges through a slit in the dorsal surface of its body.

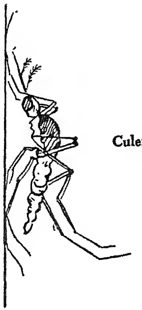


Culex pupa.

CULEX MOSQUITO.

A Culex mosquito is generally stouter in build and darker in colour than the Anopheles species. A Culex can be easily distinguished from an Anopheles by its position when at rest.

It looks like a hunchbacked insect and its body is nearly parallel with the surface on which it is resting. This position is due to its proboscis being at an angle with the body. This short description of the life history of Culex which has no importance from malaria point of view will be sufficient for the purpose of its being identified from the mosquitoes of the Anopheles species.

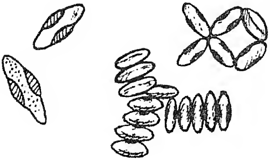


Culex adult mosquito.

ANOPHELES MOSQUITOES.—EGGS.

The Anopheles lays her eggs on the surface of water separately. Whilst laying eggs not infrequently are they laid in different patterns. This characteristic arrangement enables one to distinguish the eggs of an Anopheles mosquito from those of a Culex. Each egg has on its sides a chitinous membrane attached which helps to float the eggs on the water

surface. The eggs are hatched within a day or two as in Culex. This period may be prolonged in temperate climates and shortened in tropical regions.



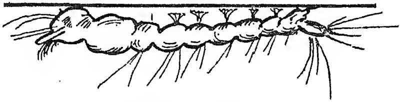
Anopheles eggs.

LARVA.

The anopheline larva has its morphological structure similar to that of the Culex, *i.e.*, it has a head, thorax and abdomen. But the main difference is in the breathing apparatus. On the eighth abdominal segment of the Anopheles larva there is a chitinous membrane plate known as the stigmal plate with two holes or spiracles which correspond with the ends of the two breathing tubes. The spiracles open in a hollow which is known as respiratory fossi. Posteriorly there is a projecting part known as scoop. On either side of the fossi there is a plate carrying teeth known as comb or pecten. Another characteristic feature of Anopheles larva is that on some of its abdominal segments there is a pair of fan-shaped hairs, one on each side. These are known as palmate hairs. By means of these and other float hairs on the body of the larva it floats horizontally under the surface of water, the eighth segment slightly projecting over the surface so as to be able to breathe through its two holes. The Anopheles larva can be distinguished from that of a Culex by the difference in the position which it assumes below water surface.

The anopheles larva floats horizontally whilst the Culex is always seen hanging at an angle. Culex larvæ feed on material suspended or deposited at the bottom whereas the anopheline larvæ subsist on floating material and they are therefore known as surface feeders. This fact is of great significance in the selection of suitable larvæcides for anti-mosquito campaigns. The larval stage of this species also lasts for eight to ten days. It may however be shorter or longer in the tropical or temperate climates respectively.

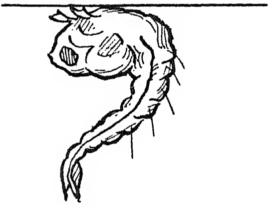
Natural size.



Enlarged Anopheles larva.

PUPA.

The pupal stage lasts for nearly twenty-four hours when the adult mosquito emerges out of the pupa. The pupæ of Anopheles can be distinguished from those of Culex by their breathing tubes which are shorter than those of Culex.



Anopheles pupa.

ANOPHELES MOSQUITO.

In general the Anopheles mosquito when compared with Culex is smaller and of a slender build. In colour too it is not so dark as the Culex but is of a brown colour and has characteristic markings on the different parts of its body.

An Anopheles mosquito is distinguished from a Culex by the position which it adopts whilst at rest. It has already been mentioned that the Culex rests with its body parallel to the surface on which it is resting whereas the Anopheles having its proboscis in the same direction as its body, when at rest, appears to be standing on its head in relation to the beam, cobweb, or net upon which it is resting.

Anopheles adult mosquito.

Morphologically there is no difference between the adult mosquitoes of the two species, Anopheles and Culex. It has been observed that only a few anophelines act as carriers of malaria. These have therefore to be distinguished

from the non-carriers with the object of adopting anti-malarial measures against the particular malaria carrying species. Certain characteristics such as differences in the markings on the veins of wings, legs and palpi and the presence or absence of these on different parts of the body are made use of in identifying the different varieties.

Structure of an adult mosquito.—A mosquito is made up of different segments. These segments which carry the appendages are the head, thorax and the abdomen. The head carries two antennæ, two palpi, a proboscis and a pair of large compound eyes composed of a large number of small lenses. The upper part of the head between the eyes is called the vertex. The part near the neck between the eyes is known as the nape. The antennæ lie between the eyes. The antenna of a female has got fourteen segments and that of a male has fifteen. Palpi have normally five segments. They are marked with bands of white and black scales which help in the identification of different anopheline varieties.

Thorax consists of three parts known as prothorax mesothorax and metathorax. Each of these parts carries on it one pair of legs. The two wings and the balancers which are the modified parts of the second pair of wings are attached to metathorax. The legs consist of three parts, femur, tibia and five tarsal segments. The part nearest the body is known as femur, the distal segments are called tarsi and the part between these is known as tibia. The last tarsal segments terminate into claws which are known as ungues. The tarsal segments and joints are important from diagnostic point of view.

The arrangement of veins on wings is characteristic of Culicidæ. The vein running round the margin of the wing is known as costa. There are six veins on a wing which are designated as longitudinal veins. The second, fourth and the fifth veins are branched and the others are simple.

The abdomen consists of nine segments which are usually covered with hairs or scales. The ninth segment carries the external genitalia which are the claspers and the cerci in a male and female mosquito respectively.

GENERAL HABITS OF MOSQUITOES.

Both males and females are able to suck fluid through their proboscis. As a rule, the male feeds only on the juices of plants, but the female sucks the blood of man, beasts, birds and reptiles. The female returns to water every few days in order to lay her eggs, of which she may deposit several hundreds at a time; and then seeks another meal. Female mosquitoes have been kept alive in captivity for months. In unsuitable weather, both males and females may take refuge in damp places such as cellars, wells, outhouses, stables and woods, where they may remain dormant for months until better conditions prevail.

As a rule, mosquitoes like other animals tend to remain in the locality where they are born; but a few may occasionally stray to some distances. When a strong wind prevails they usually take shelter but on warm still nights or days many of them may wander to a distance of half a mile or more from their breeding places. If however they can obtain blood near their breeding place there is no reason why they should travel further for it. They must remain near water to drink and to lay their eggs on.

Mosquitoes are favoured by warm weather and by plenty of water suitable for their larvæ; by abundance of food and by the absence of the various kinds of bats, birds, fish, insects and spiders which devour them or their larvæ. During its life a single mosquito may succeed in biting many persons or animals and in propagating disease amongst them.

ANOPHELES IN INDIA.

The following species of Anopheles mosquitoes have been found in India :—

1. A. barianensis.
2. A. aitkenii.
3. A. insulae-florum.
4. A. culiciformis.
5. A. sintoni.
6. A pulcherrimus.
7. A. pallidus.
8. A. philippinensis.
9. A. fuliginosus.
10. A. karwari.
11. A. majidi.
12. A. maculipalpis
13. A. theobaldi
14. A. jamesii.
15. A. ramsayi.
16. A. kochi.
17. A. maculatus.
18. A. leucosphyrus.
19. A. tessellatus.
20. A. annandalei.
21. A. lindesaii.
22. A. hyrcanus.
23. A. barbirostris.
24. A. umbrosus.
25. A. gigas.
26. A. subpictus.
27. A. vagus.
28. A. turkhudi.
29. A. multicolor.
30. A. dthali.
31. A. sergentii.
32. A. culicifacies.
33. A. minimus.
34. A. aconitus.
35. A. varuna.
36. A. listonii.
37. A. superpictus.
38. A. moghulensis.
39. A. jeyporiensis.
40. A. stephensi.
41. A. ludlowii.

Out of these the following six have been so far found infected with Malaria in nature and play an important role in the transmission of the disease :—

1. A. culicifacies.
2. A. listonii.
3. A. ludlowii.
4. A. maculatus.
5. A. minimus.
6. A. stephensi.

DIAGNOSTIC CHARACTERS OF THE MALARIA CARRYING MOSQUITOES.

(1) A. culicifacies—
(*a*) At least four dark areas on costa involving both the costa and 1st longitudinal vein.
(*b*) Joints between tarsal segments of fore leg without broad pale bands.
(*c*) Palp of female with a pale tip.
(*d*) Third longitudinal vein all dark.

(2) A. listonii—
(*a*) as in (1).
(*b*) as in (1).
(*c*) as in (1).
(*d*) Third longitudinal vein with a pale area or entirely pale.
(*e*) Palp of female with two pale distal bands, the second pale band usually narrow. The dark band separating these wider than the apical pale band.
(*f*) Scales present only on the anterior one-third of thorax.

(3) A. ludlowii — (a) Tips of hind legs not white
(b) Femora and tibiæ speckled.
(c) Sixth vein with three or less dark areas.
(d) Palp of female with one broad apical and two narrow more proximal pale bands. Palps not speckled. Dorsum of thorax clothed with hairs.

(4) A. maculatus —(a) Tips of hind legs white.
(b) Less than two terminal hind tarsal segments completely white.
(c) Sixth wing vein with three dark spots only.
(d) Whole of the terminal hind tarsal segment and part of the next white.
(e) Palp of the female with three well-marked pale bands including apical band.

(5) A. minimus — (a) as in (1).
(b) as in (1).
(c) as in (1).
(d) as in (2).
(e) Palp of female with two pale distal bands both broad, separated by a dark band this dark band about equal in width to the pale apical band, or it may be narrower.

(6) A. stephensi — (a) as in (3).
(b) as in (3).
(c) as in (3).
(d) Palp of female with two broad distal and one narrow proximal pale bands. Palps usually speckled. Dorsum of thorax clothed with obvious true scales.

LARVICIDES.

It has been stated before, that mosquitoes can be effectively attacked during their larval stage of life. Most of the measures for controlling mosquitoes must be applied to this acquatic form of their existence. Larvicides are substances which kill the larvæ. Those commonly used for this purpose are certain oils, chemicals and certain kinds of fish.

The oils act mechanically. When water containing larvæ is sprayed with oil, it forms a film and floats on water surface. The oil film obstructs the air passages of the larvæ which are killed by suffocation or in some cases the oil itself may act as a poison.

Chemicals have a poisonous effect on the larvæ. Disinfectants such as Phenyle, Hycol, Saponified Cresol and others are useful for larvicidal purposes. The other chemical which has come into prominence as an efficient and less expensive larvicide in recent years is "Paris Green."

Fish acts as a larvicide by merely feeding on larvæ. All kinds of fish do not, however, consume mosquito larvæ. A few varieties have so far been found to be useful for this purpose. The larvæcidal capacity of any variety of fish must be investigated by experiments in which a check or control is maintained.

OILING.

Mosquito breeding can be largely controlled by oiling.

There are many grades of oil on the market which will serve for the destruction of larvæ. The oils which are commonly used for this purpose range from the very light oils, such as kerosene, to the heavier oils, known as crude oil. Kerosene or paraffin oil is suitable, but it is not used for larvicidal purposes on a large scale as it is very expensive, compared with crude oil. Crude oil which is also known as pesterine is largely used for anti-mosquito campaign. The disadvantage in the use of crude oil is that it being more viscous than kerosene oil forms into clots and does not form a good film which is so essential for the destruction of larvæ. The spraying quality of crude oil can be improved by the addition of small quantities of some vegetable oil, such as Castor or Cocoanut Oil or Cresol. A mixture of crude oil, kerosene and a little castor oil has been found to be very effective. The mixture is prepared by mixing together 6 parts of Pesterine or Crude Oil, 4 parts of Kerosene and 1/40th part of Castor Oil. A mixture of this strength is used in Bombay and one gallon of it costs about 5 to 6 annas.

As compared with chemical larvicides, oil has a more lasting action and besides it kills larvæ as well as pupæ of both Anopheles and Culex mosquitoes. The other advantage in the use of oil is that it can be seen on the water surface.

METHODS OF APPLICATION.

It is not practicable to state definitely the quantity of oil required per unit of area. It very often depends on the spreading quality of the oil and also on the experience of the personnel employed on oiling squads. If all these conditions are favourable it may be laid down for general guidance that half an ounce of oil per square yard of water surface or 15 gallons per acre is usually an ample estimate. The exact amount of oil required in a particular case must be estimated by actual experiments in the field. Water surfaces may be oiled by using:

1. A garden watering-pot.
2. Knapsack sprayer, or any other oil spray.

The watering-pot may be used efficiently in dealing with small pools or where it is easy to get near all parts of breeding places. A relatively thick oil can be employed in this way.

For anti-mosquito campaigns, Knapsack sprayers have been found to be very serviceable as they can be easily operated. Light oil or crude oil made into a proper mixture is finely spread on water surface upto a distance of 20 feet from the operator by means of these sprays.

The advantage in the use of a Knapsack sprayer is that it can be used by one man without wasting oil. The machine holds five gallons and rests on the shoulders and back of the operator. He pumps with one hand and directs the oil spray with the other. With this spray the work is less tiring than using a watering-pot. It gives excellent results as regards the proper distribution of oil.

CHEMICAL LARVICIDES.

Disinfectants such as Phenyle, Hycol or Saponified Cresol are all useful for destroying mosquito larvæ. They are however expensive and are not effective for flowing water. Their use is advocated with the object of preventing breeding in collections of water which will not permit of being dealt with in any other manner.

Saponified Cresol has in recent times been used for larvicidal purposes more than any other disinfectant. A strength of 1 in 10,000 is probably sufficient to prevent breeding but it will be more reliable if a strength sufficient to render the fluid milky is insisted upon, in which case the dilution may be in the proportion of 1 in 2,000.

Saponified Cresol has been found to be suitable in the case of reinforced concrete buildings. When such buildings are under construction it is a practice to store water on the newly laid out concrete flooring and other structures. The water which is pounded for setting concrete is liable to be a source of mosquito breeding. With a view to preventing breeding in such water the use of Saponified Cresol is recommended as its presence can be easily detected owing to the milky colour of the fluid. Tests carried out by analytical chemists and specialists in cement and concrete have proved that in a strength of one in one thousand this larvicide not only has no deleterious effect on cement concrete but it improves its quality.

PARIS GREEN.

Paris Green has gained great favour as an efficient Anopheline larvicide. It is an Arsenical compound and is manufactured as Copper-Aceto-Arsenite. It is an intensely green coloured fine powder. For larvicidal use Paris Green must contain at least 50 per cent. Arsenious Oxide. When a new supply of the powder is received it should be the practice to test the sample for the available quantity of Arsenious Oxide.

The powder is applied to water surfaces in a greatly diluted form. The diluents ordinarily used are fine sand, saw dust, dry road dust, soft stone or soap stone. Hydrated lime is also used for diluting Paris Green as the advantage in the use of lime is that it enables the mixture to remain floating longer than in the case of other diluents. Other diluents, such as Stearates of Calcium and Aluminium have

also been recommended with the same object. The use of these diluents will make the process expensive. Of all these diluents, road dust of fine quality has been found to be sufficiently serviceable for all practical purposes. A sufficient stock of road dust should always be kept at hand as in the wet weather it would be difficult to obtain a suitable supply of dry dust.

A dilution of about 1 part of Paris Green to 99 parts of the inert dust seems to be a favourable mixture. The mixture should be made in a specially contrived mixer to ensure thorough mixing. Only very small doses of Paris Green are necessary to poison larvæ, but the object of diluting it with a large proportion of dust is for spreading a relatively small quantity of the poison over a large surface.

METHODS OF APPLICATION.

Various methods have been adopted for spraying Paris Green mixture but hand spraying has been found to be quite satisfactory. The dust should be thrown into the air by hand and the main thing to be seen is to start a cloud of dust in the right place and direction. A single cloud may destroy larvæ over a wide area and at a considerable distance from the operator if the dust is thrown in the windward direction. For hand spraying a mixture of 1% to 2% strength should be used.

Other devices used for spraying dust are certain types of hand blowers, rotary blowers and dust guns. These have apparently been designed to facilitate spraying at longer distances but are liable to be misused unless they are put in the hands of trained men. For use in such mechanical blowers a mixture of 5% strength is recommended.

The quantity of Paris Green to be used must depend somewhat on the character of the breeding place. Where there is much high grass, reeds and other thick vegetation greater quantities of the mixture are required than where the

surface of the water is clear or covered by low surface vegetation only. According to the recommendations of the Malaria Commission of the League of Nations one litre of the mixture is sufficient for 100 square metres of water surface or 1 lb. of Paris Green per acre.

Paris Green being a compound of Arsenic which is a poison, there has been a good deal of discussion about its harmful effects on human beings and animals who may have to drink water treated with this chemical. In this connection it must be remembered that the poison is used in an infinitesimally small quantity and that the Arsenic which it contains is in the insoluble form. Poisonous effects of the chemical have not been observed on any aquatic insect or animal, however delicate, other than the surface feeding anopheline larvæ. The danger to domestic animals through drinking water treated with Paris Green seems also remote.

As regards the risk of Arsenic poisoning to the operator even with the small quantities used in larvicidal work, it is well to remember that one is dealing with a poison. The operator should as far as possible avoid inhaling the dust and after the work he should thoroughly wash his hands and change his clothes.

In the use of Paris Green it must be remembered that it has poisonous effect on anopheline surface feeding larvæ only. These larvæ feed on any material floating on water surface and are poisoned by ingesting minute particles of the poison. It has no effect on the pupæ but it prevents the development of larvæ into pupæ.

The possible advantages of Paris Green used against anopheline larvæ are its cheapness and ease of distribution and it is possible to use it over areas difficult of treatment by other methods. The chief disadvantage is that its use is limited to anopheline larvæ only. Pupæ of all kinds and culicine larvæ are not at all affected by it. The efficacy of

Paris Green is seriously lessened by wind and rain after it has been sprayed on water. Of all the measures for mosquito control Paris Green has been most successful as an effective and cheap anopheline larvicide.

ADVANTAGES OF OILING AND PARIS GREEN.

Oil.	*Paris Green.*
(1) It kills culicine as well as anopheline larvæ.	(1) Its low cost.
(2) It is obtainable everywhere.	(2) Its ease of distribution by wind.
(3) It is easy to see whether it has been properly applied.	(3) Its high toxicity for anopheline larvæ.
(4) No elaborate apparatus is required for its application.	(4) Water is not rendered unfit for domestic purposes.
(5) It does not require much supervision.	(5) It does not prevent mosquitoes from depositing their eggs, the water treated thus acting as a trap.

DISADVANTAGES OF OILING AND PARIS GREEN.

Oil.	*Paris Green.*
(1) It will not penetrate vegetation.	(1) It has no effect on the egg or pupæ of anopheline mosquitoes.
(2) Wind will break oil film and carry the oil on one side.	(2) It has no effect on culicine larvæ.
(3) Rain washes away oil.	(3) Its application cannot be properly inspected.
(4) It will kill fish.	(4) Special apparatus required for its distribution.
(5) It renders water unfit for drinking purposes.	(5) Its use requires constant supervision.

USE OF FISH AS LARVICIDE.

Certain kinds of fish, particularly some of the top feeding varieties, have been found to be very effective for mosquito control in its larval stage. Among Indian species some have been found to be of great use for mosquito control. There are probably many more and the subject requires further investigation. If fish is to be employed for mosquito control, as far as possible, the larvivorous properties of locally obtainable fish should be ascertained by experiments. It is advantageous to use local fish as when imported to regions outside its natural place it may not probably thrive well.

FISH STOCK FOR MOSQUITO CONTROL.

Having ascertained the larvivorous variety of fish it is necessary to maintain a constant stock of fish so as to use them in any breeding places of mosquitoes whenever needed. Small ponds or streams which hold water throughout the year may be conveniently used for stocking fish. It is however necessary to see that there is no other fish which may destroy or live on the larvivorous fish. The best method of stocking fish is to provide a masonry built tank. The dimensions of such a tank will depend on the quantity of fish required to be stored and it must also be remembered that fish is very prolific and therefore the tank should be of a sufficiently big size to provide room for the progeny. Arrangements should be made to replenish the water frequently. As regards feeding the fish, minced fish, bread, corn meal, parched rice, etc., are found to be suitable.

In places where fish is to be used for larvivorous purposes it is essential that fish stock should be in charge of a responsible person. This official should be responsible for the collection, storage and distribution of fish according to local requirements.

As regards the quantity of fish necessary to control breeding of mosquitoes, no definite rules can be laid down as there are scarcely two breeding places which offer identical conditions. It is advisable to ascertain the quantity by actual observation after the introduction of the fish. As a rule in ponds or other collections of water with much vegetation, larger number of fish would be necessary. This is due to the fact that mosquito larvæ seek refuge in the vegetation and thus the fish is unable to reach them. All aquatic plants do not offer protection to mosquito larvæ and pupæ against fish. Grasses and other plants having straight stalks and no submerged leaves afford no protection. In the case of plants with submerged leaves larvæ remainunnoticed in the water on the surface of the leaves.

Growth of algæ also very much interferes with the action of fish on larvæ. Before the introduction of fish in any water collection in which there is algæ, it is advisable to kill the algæ by means of Copper sulphate. For this purpose Copper sulphate in the proportion of 1 in 500,000 parts of water may be used, but this treatment must be repeated very frequently. Other aquatic vegetation should also be removed as far as possible to make the fish effective.

Different varieties of fish have been found to be useful for larvivorous purposes. In America and in some European countries a variety known as Gambusia is being largely used as an effective larvicidal fish. This fish has recently been introduced in India. In India there are various species which have been found to possess larvivorous habits. In Bombay only two varieties of fish have been found to be useful for this purpose. They are found in shallow collections of water during monsoon and if they are properly stocked they thrive well. They are known as Anabas scandens and Haplochilus Lineolatus but are locally known as Khajura and Piku respectively. Out of these two the former is a sturdier fish and is very effective as larvicide. It thrives well even in the presence of other small fish whereas Piku is easily destroyed by other fish. One dozen of Khajura are considered to be sufficient for mosquito control for fifteen square feet of water surface.

INCIDENCE OF MALARIA.

The incidence of Malaria in a locality can be determined by the consideration of the following :—

(*a*) Mortality Registration,

(*b*) Hospital or Dispensary Records,

(*c*) Splenic Index,

(*d*) Parasitic Index,

(*e*) Infection among the Anopheles.

(*a*) *Mortality Registration.*—Where registration of the cause of death is done accurately from the certificate of a medical practitioner, these records have a high value. But in villages and in many cases in towns also, deaths are not always certified by qualified men. Hence this method is valueless directly, yet as Christopher and others have shown if properly used, it has a considerable comparative value.

(*b*) *Hospital or Dispensary Records.*—These records though more reliable than the preceding ones, must be accepted with a certain amount of caution. It is not that in every case of fever supposed to be malaria, that blood is examined and this holds true more particularly if the fever is mild or of short duration. Even after blood examination, if the report is negative, the clinical diagnosis is rarely altered because the plea is put forward that the parasite is not found in the blood in every case of malaria or the patient may have taken quinine before admission. Para-typhoid fevers are often entered and treated as malaria. These considerations detract from much of the value of hospital records and though of little value directly, they are useful for comparative purposes over a series of years. The records of an out-patient department are of greater value in this connection.

(*c*) *Splenic Index.*—This has been taken as the criterion of the malariousness of a locality since the early days of malaria investigation. Children between the ages of 2 and 10 are most suitable for the purpose because firstly it is easier to get them together in sufficiently large numbers as *e.g.* in a school and secondly, in the adults, splenic enlargement becomes much less common owing to their having acquired a partial immunity as a result of long exposure to infection.

Splenic enlargement may be measured with the child standing up or lying down. It is necessary to adopt one or the other method and stick to it. Occasionally a doubtful result in the erect position may be checked by laying the

child on its back with the knees drawn up. The children may be induced to submit themselves to the examination by giving each child a sweet after the examination. A child who struggles or screams maybe left alone till others are examined, after which a fresh attempt may be made to examine it with the additional bait of a few more sweets. The enlargement of the spleen is usually recorded in "fingers-breadth" below the left costal margin. Upto the umbilicus, it may be taken as "four fingers-breadth" and the "seven fingers-breadth" spleen is one which reaches right down to the pubis.

(*d*) *Parasite Index*:—This is a simple percentage figure of the number of persons showing parasites in their peripheral blood. The blood should be examined both by the thick and thin smear methods. The child and adult figures should be kept separate as the spleen rate falls with age more rapidly than the parasite rate, which shows how many of the adults of a community may be "healthy carriers" (Christophers).

By this method, we come to know also about the species of parasite we are dealing with, which is important from the point of view of treatment. From a count of gametocytes, we get an idea as to what chance the local anopheles stand of acquiring infection. If many gametocytes are detected, the probability is that the local anopheles are heavily infected. This may be confirmed by studying the next factor.

(*e*) *Infection among the Anopheles*:—For this purpose, it is necessary to catch a few Anopheles and dissect them. Only the females need be dissected. The stomach should be examined microscopically for the oöcyst and the salivary glands for the sporozoites. This examination should not be limited to the known carriers but a few of the non-carrier species should be examined as well.

PREVENTIVE MEASURES.

Preventive measures against Malaria may be considered under two headings, *i.e.*, personal prevention and public prevention.

PERSONAL PREVENTION.

AVOIDANCE OF MALARIOUS DISTRICTS.—If it can be avoided people should not go to live in known malarious places nor in the vicinity of marshes. It very often becomes necessary to select suitable sites for the construction of public buildings such as hospitals, police lines and other institutes or for the erection of temporary or permanent camps for labourers. In the selection of such sites the prevalence of malaria in the neighbourhood must not be lost sight of. It should always be ascertained by a careful examination of children under ten years of age for enlargement of their spleens.

Mosquito-proof cottages or rooms.—The construction of mosquito-proof buildings on a large scale is not a practical proposition. But on big plantations of rubber and tea in Ceylon and Assam such residential quarters have been built. The windows and doors of such dwellings should be protected with wire gauze. The gauze to be used for the purpose should not have less than sixteen meshes to an inch, or in other words there should be no aperture bigger than $\frac{1}{16}$th of an inch. The doors should be made to open outwards and they should be provided with automatic closing arrangements. It is especially advisable to protect a room or a part of a verandah for sitting in, during the day or evening.

MOSQUITO NET.

Sleeping beneath an efficient net at night is by far the most important and effective means of guarding against a primary attack but also of preventing infection being carried from a sick person to healthy individuals. The main points in regard to the efficiency of a mosquito net are that the mesh should not be too large; that the bed for which it is used should not be so narrow as to allow of knees or elbows being bitten through the netting; and that the sides should be deep enough to admit of being tucked in securely all round.

The smallest and lightest mosquito net which can be made serviceable under all circumstances is one with a calico top 5 ft. 6 in. long by 2 ft. broad and sides 3 ft. 6 in. deep, 2 ft. of netting and $1\frac{1}{2}$ft. of calico for tucking in, and as some protection for knees, feet and elbows. The netting should be so cut as to allow the net to be very much fuller at the bottom than at the top to enable the occupant to get in and out conveniently. At each of the four corners of the net there must be double tapes 8 in. long for fixing it to its supports. To be efficient it must be suspended by means of these corner tapes inside the supporting rods, otherwise it cannot be tucked in effectively. On no account should it be placed over its supports or allowed to hang loose.

USE OF DETERRENT LOTIONS.

One of the methods of personal protection against mosquito bites is the application of deterrent lotions. One which is commonly used in mosquito infected localities is Bamber oil. This was first introduced in Ceylon. It is a thin lotion with a pleasant citron like smell and leaves no stains on clothes. When a mosquito net is not available or cannot be used, the application of this oil is sufficient for a night's rest in comparative safety.

The composition of Bamber oil is as follows :—

Citronella Oil	$1\frac{1}{2}$ parts.
Kerosene (paraffin oil)	1 part.
Cocoanut Oil	2 parts.
To which is added Carbolic Acid ..	1 per cent.

This is one of the most efficacious, agreeable and clean mosquito deterrents.

Dover's pomade consisting of citronella oil, spirit of camphor, cedar wood oil and white petroleum jelly and other preparations made of (*a*) vaseline, naphthalene and camphor and (*b*) castor oil, alcohol and oil of lavender are also used as effective repellents. Among other substances recommended,

may be mentioned eucalyptus oil, oil of peppermint, lemon juice and vinegar and oil of turpentine.

FUMIGATIONS.

For destroying or reducing the number of mosquitoes in a room fumigation with certain chemicals is found effective. Among those ordinarily recommended for the purpose are Sulphur, Pyrethrum, Carbolic Acid and Camphor.

QUININE IN MALARIA.

Quinine and other cinchona alkaloids and the newly discovered drug Plasmoquine are the only drugs so far known to be useful for the cure of Malaria. The quinine alkaloids are all prepared from Cinchona bark. Quinine acts as a specific for malaria but it has no effect on the sexual forms of malignant tertian parasites. It cannot therefore sterilise a crescent carrier who is always a danger in a community by harbouring these gametocytes in his body.

Quinine destroys both the sexual and asexual forms of Benign tertian and Quartan parasites. In these types of fever it is therefore possible to effect a complete cure by quinine alone. Plasmoquine is found effective in destroying the sexual forms of the malignant tertian parasites. This drug has however no effect on the asexual forms of malignant tertian parasites and it is therefore always necessary to combine Plasmoquine with quinine for treating such cases. Plasmoquine being poisonous has to be administered in very small doses and it is always desirable that it should be given under medical supervision to avoid its poisonous effects.

As regards the dose of quinine it is necessary to administer at least 20 to 30 grs. of the drug daily for a cure of malaria. An important consideration in the treatment of malaria is to see that quinine administered to a patient is absorbed. There is always vomiting in cases of malaria and the drug is not easily absorbed; this can be remedied by giving a purge and an alkaline mixture before administering quinine. The

treatment should be continued for one week and in the case of a relapse it should be repeated again for a longer period about 14 to 21 days for a complete cure.

Prophylaxis.—Quinine does not act as a prophylactic against malaria infection but it may be considered as a prophylactic against the fever. It modifies the attack and will reduce the number of clinical cases. It probably reduces the number of potential Benign tertian carriers. Quinine taken as preventive generally acts as treatment.

QUININE IN PREGNANCY.

Quinine can be safely administered during pregnancy. It is a wrong notion that it causes miscarriage. The high temperature of the disease is responsible for miscarriage and not quinine. Comatose cases of malaria are common among pregnant women. Quinine should always be started early for malaria in such cases.

WHAT A HOUSE OWNER SHOULD DO.

It is not uncommon to find householders complaining to local sanitary authorities about mosquito nuisance although they themselves allow them to breed inadvertently on their own premises. The householder should always take care that no stagnant water remains anywhere in his premises in cisterns, drains, gutters, tubs, jugs, flower-pots, broken bottles, crockery and old tins in which mosquitoes are likely to breed. Flower-vases and anti-formicas are very common breeding sources of mosquitoes inside houses where care is not taken to change the water frequently. It should be a rule to change the water in flower-vases every day and that in the anti-formicas either to change the water at least once in a week, or to put a little kerosene oil or phenyle in it. Holes in trees or certain plants such as the pine apple hold water in which mosquitoes not infrequently breed. The holes should be filled in with cement and the water collected in other plants should either be drained or treated with kerosene oil.

Owners of properties should make it a habit to see at least once a week regularly to all the water containers on their premises, as by attending to all such potential breeding places in the manner indicated above they will be helping a great deal towards the reduction of mosquitoes.

PUBLIC PREVENTION.

The local sanitary authority must necessarily be the body responsible for all anti-malarial measures and it should be invested with the necessary statutory powers for effectively carrying out the measures.

Measures for the public prevention of malaria have to be considered separately for the rural and urban areas owing to the differences in the conditions particularly those prevailing during and after monsoon in these areas.

MALARIA PREVENTION IN RURAL AREAS.

In rural areas where conditions are favourable climatically and geologically for anophelines to breed malaria prevails in epidemic form during a few months following monsoon generally from August to December or a little later and remains endemic during the whole year. It is generally held that the intensity of the post-monsoon epidemic is influenced by the rainfall and consequent breeding of anophelines particularly those of the malaria carrying species. In rural districts it is not uncommon to find children with enlarged spleens acting as reservoirs of malaria parasites though apparently looking healthy. When there is an increase in the malaria carrying anophelines after a monsoon the disease is spread from these danger zones by them and the disease assumes an epidemic form.

In rural districts the absolute reduction of mosquitoes is an impractical proposition but it may be possible to attempt to reduce to some extent, if not to eradicate the species of mosquito which may be found responsible for the spread of malaria in a particular area.

Anti-larval measures carried out strictly within the limits of a village will not be of much benefit as the breeding places round about the village will remain untreated and be a fruitful source of mosquitoes to the village. On the other hand, treatment of the whole area in between adjacent villages is impracticable. It is therefore necessary to know as to how far round a village, should the anti-larval operations be extended. The Malaria Commission of the League of Nations in their study tour in India decided that this limit should be half a mile all round, provided there were no large breeding places just outside this limit (Report of Malaria Commission on India). In regions with little breeding, this area may be narrowed further whereas, according to Senior-White, "anti-larval work would be practically impossible if the limit had to be extended over half a mile".

DRAINAGE.

In hilly districts there is comparatively less possibility of rain water accumulating and remaining stagnant sufficiently long for mosquitoes to breed as water flows down the natural water courses of the country. But in the low lying districts situated away from the natural drainage the lands remain under water for a considerably long time with the result that mosquito nuisance increases and practically remains constant until the water is either absorbed by land or evaporated.

Drainage as applied to mosquito control is quite different from the usual meaning of the term "drainage." For mosquito eradication it is not enough to drain the land properly but the drainage ditches must be so planned, constructed and attended to that they will not become a source of mosquito breeding. It is known that mosquitoes breed more favourably in shallow water than in deep water, even a depth of an inch is sufficient. Ditches are constructed chiefly for disposing of storm water but subsequently when normal water line is reached the ditches may hold water which though small in quantity may favour mosquito propagation.

Drainage from an anti-mosquito point of view may be considered under the following heads :—

1. Training natural streams and water courses.
2. Subsoil drainage.
3. Filling.

Training and Treatment of Small Streams and Natural Water Courses.—It is believed that mosquitoes breed only in stagnant water but mosquito larvæ have often been found in large numbers in streams with a fairly good current. It is possible that in most streams the velocity of the current is markedly decreased owing to formation of irregularities in its course. It is in such places that the water is almost, if not absolutely, stagnant.

A stream or a ditch should be made to have steep banks directly above and below the flow line, uniform grade and width and as far as possible a straight course. They should be free from any growth of vegetation, sticks, stones, or other obstructions that would interfere with the current.

Subsoil Drainage.—Subsoil drainage is useful in connection with mosquito control for two purposes :

(*a*) To lower the water table or ground water so that pools or surface water will be absorbed more rapidly by the soil.

(*b*) To intercept seepage planes and prevent seepage water from hill sides reaching and collecting on the surface of the ground.

Drain tiles are used for this purpose. The size of the tiling may range from 3 inches to 12 inches in diameter and 1 to 2 feet in length. The tiles are placed underground, end to end, and covered with earth. They are generally laid at the depth of 2 to 4 feet.

Subsoil drainage must be protected from traffic wherever roads pass over it. The outlets must also be regularly attended to and any clogging caused by earth or other material should be removed. The chief advantage of subsoil drainage is that it permits of no water surface being exposed to mosquitoes. The other advantage of this method as compared to open ditches is that it is self-cleansing, maintains itself in good condition, permits of easy inspection, needs very little attention and besides requires no oiling. The disadvantage of subsoil drainage is that it is expensive.

Filling.—Collections of water which it may not be possible to drain should be removed by filling with dry refuse or earth. When the filling material consists of town refuse care should always be taken to exclude broken crockery, bottles, old tins and other articles which are likely to hold water in the rainy season. If any such articles are included in the filling materials they should be covered over with earth so as to do away with the possibility of their holding water and becoming a source of mosquito nuisance.

One of the advantages of filling is that shallow water in areas which are too low to be drained is concentrated and the remaining body of water is easier to control. In filling with earth or clay care should be taken not to leave depressions on the filled up portion which may hold water.

In addition to these measures as a matter of personal protection house owners as far as possible should try to eliminate sources of mosquito breeding in the immediate vicinity of their houses. Depressions which may hold water should be filled with earth, or small collections of water should be oiled periodically.

The use of mosquito nets combined with quinine administration is always advocated for personal protection against malaria. Mosquito nets can however have no practical application in India as the economic condition of the masses

particularly of those living in rural districts is so poor that it would be unwise to rely on this measure for personal protection against malaria.

QUININE AND RURAL MALARIA.

Quinine is of great value as a curative in rural malarial districts provided it is made available in such places for the people. Arrangements are made by Government Medical Department for the sale of quinine at comparatively cheap price in villages through Post Offices or schools. Villagers generally take advantage of these facilities and during the malarial season there is always a general demand on this supply. During the malarial season which generally sets in soon after monsoon and prevails from September to December, medical aid is also rendered to people suffering from malaria by temporarily appointing Medical Officers. These officers visit villages and treat patients for fever and other complications.

Bonification—The term "bonification" generally signifies all work carried out with the object of making regions that are periodically or permanently marshy, more healthy and more suitable for agriculture. The results of bonifications are direct and indirect.

The direct consequences are the changed hydrographical conditions: lakes, sea inlets and swamps are converted into dry land and protected against repeated inundations, the level of the subsoil water is lowered as a consequence of drainage or is raised as a consequence of irrigation.

The indirect consequences are the changed economic conditions: building of towns and villages, agriculture, new roads, etc. They may lead to a rise of the economic status of the indigenous population and in that case the indirect consequences are social as well as economic.

There can be no doubt that the work of bonification may lead to a reduction or even complete abolition of breeding places.

There is no difference of opinion on the good influence of agricultural bonification in decreasing the incidence or, at least, the gravity of malaria (Second general report of the Malaria Commission, League of Nations).

MALARIA PREVENTION IN URBAN AREAS.

Measures to be adopted for the prevention of malaria have to be devised on different lines for (1) towns in which there is no public water supply and sewerage system and for (2) towns which have a public water supply and a complete sewerage system.

ANTI-MALARIAL MEASURES IN URBAN TOWNS WITHOUT PUBLIC WATER SUPPLY AND SEWERAGE.

Except a few towns most of the towns in India have to depend for their water supply on wells, tanks and other temporary collections of water. In the absence of drainage or sewerage for most of the towns the methods of sewage disposal are very unsatisfactory. The waste water is allowed to drain into pits or low lying lands. Such collections of water become sources of mosquito breeding. In such water the mosquitoes which breed are generally of culex variety and there is no danger from these from the malaria point of view, but all the same they cause a good deal of annoyance by biting and are therefore a great nuisance.

Urban towns of the above description are faced with malaria problem on account of the breeding of mosquitoes of the anopheles variety in wells, tanks and other collections of fresh water.

MEASURES AGAINST ANOPHELINES.

Wells.—It is said that mosquito eggs do not hatch in wells which are in use as they are destroyed by the disturbance

of water. This is however not correct as mosquitoes have not infrequently been found breeding in such used wells. The anopheles mosquitoes, as has been stated before, prefer to lay their eggs on the surface of clean water such as is found in wells which are in use. In urban towns which depend for their water on wells, they are a source of danger from malaria point of view.

Where it may be possible, wells may be protected from mosquitoes by covering them and water may be drawn by means of a pump. The cover may be made of cement concrete which will last long and render the well hermetical. This measure can however have no general application in most of the towns owing to the habits of the people who will not find a pump satisfactory for drawing water.

Mosquito breeding can be checked efficiently by stocking wells with larvicidal fish. In the presence of too much vegetation in wells fish cannot attack effectively the larvæ as they find protection in the weeds and other vegetation. As a rule in wells which are in daily use there is not much vegetable growth but such is not the case with tanks as they contain algæ and other vegetable growth. In such tanks larvicidal fish does not act effectively as the larvæ seek protection in the vegetation. If fish is to be used for larvicidal purposes it is necessary to clean the water of all the vegetation. It is difficult to get rid of the algæ but this can be done to some extent by adding copper sulphate to the water. Fish should be introduced after cleaning the water thus. Nothing can be said definitely as regards the quantity of fish required but the same can be determined by observing the effect of the fish introduced in a particular well.

Oiling.—Wells which are not in use for drinking purposes may be oiled regularly at least once in a week. This will kill larvæ of all the species of mosquitoes.

Use of Chemicals.—When anopheline mosquitoes alone are found breeding Paris Green may be sprayed on the water surface for destroying the larvæ. It should be used once a week regularly to prevent the larvæ developing into adult mosquitoes. The advantage in the use of Paris Green is that it does not render the well water unfit for domestic purposes for several days as happens in the case of oiling.

ANTI-MALARIAL MEASURES FOR URBAN TOWNS HAVING A PUBLIC WATER SUPPLY AND SEWERAGE SYSTEM.

Bombay can be taken as an example of such a town and all the anti-malarial measures adopted there may be beneficially introduced in any other town under similar conditions.

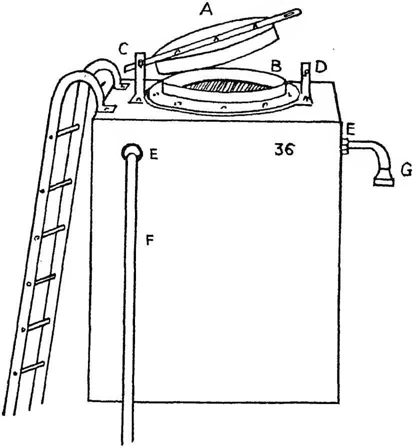
ANTI-MALARIAL MEASURES IN BOMBAY.

Anopheles stephensi is the malaria carrying mosquito in Bombay. All water containers to which this mosquito is likely to gain access must therefore be protected against its entry. It has been observed that this mosquito prefers to lay her eggs in clean water. All domestic water cisterns and every other collection of clean water are potential breeding places of this mosquito. Anti-malarial measures must therefore be concentrated on the control and eradication of this mosquito.

The following measures are adopted for the Anopheles stephensi in particular and mosquitoes in general :—

(1) *Domestic Cisterns.*—Most of the houses have water storage cisterns for domestic use and for flushing water-closets. If any such cistern is in a non-mosquito-proof condition Anopheles stephensi has been invariably found to breed in it. These cisterns must therefore be considered to be

dangerous potential sources of breeding and must therefore be guarded against the mosquito. Mosquito-proof cisterns have specially been devised from this point of view.



DOMESTIC CISTERN.

a Manhole cover cast in one piece; *b* Manhole collar with rim; *c* Hinge; *d* Hasp; *e* Checknuts; *f* Feeding pipe; *g* Warning pipe with protector.

A cistern is made of wrought iron plates and all its sides are firmly secured by means of rivets. It has an opening in the top sheet known as the manhole. A cast iron rim with a collar is fixed on this manhole which is provided with an iron cover cast in one piece. This cover is fixed on to the manhole rim by means of a hinge and a hasp. The bar across the top of the lid should be short so that both

hinge and the hasp are as close to the lid as possible. This is done to ensure proper closing of the lid and putting on a lock. The other standard parts of a cistern are a feeding pipe, an overflow or warning pipe. The feeding pipe is fixed in one of the side sheets and at its junction with the sheet a checknut is provided with a view to leave no chink around the pipe. The same precaution is observed as regards the outlet and overflow pipes. The overflow pipe is provided at its free end with a standard pattern cap to protect it against the entry of a mosquito in the cistern through the pipe. This protector consists of a brass ferrule provided with a brass plate having perforations not bigger than $\frac{1}{16}$th of an inch in size. It can be easily fixed to the end of the pipe.

The lid of every cistern is required to be kept under lock and key or a bolt and nut and any unnecessary interference with this arrangement is dealt with under the law.

Each cistern is numbered in a serial order so that there may not be any possibility of omitting to inspect any cistern during the weekly routine inspections. To facilitate easy and quick inspection of domestic cisterns provision of easy and safe means of access is also made compulsory. It is insisted that an iron ladder should be fixed permanently for every cistern so as to make it easily accessible, where no other safe means of access exist.

There are about 37,000 cisterns in Bombay. The work of the Malaria Department is so organised that every cistern must be examined as regards its mosquito-proof condition once a week regularly as a matter of routine. If any defects are noticed steps are taken immediately to put it in proper order by issuing statutory notices requiring the work to be done within a week's time.

(2) *Wells.*—In ancient times wells formed one of the important sources of drinking water supply in many Indian cities. But with the improved means of public water supply

they have outlived their utility and from the point of their being favourable potential breeding places of mosquitoes are a menace to public health. Bombay may be quoted as a striking example of this. With sufficient public water supply private wells are hardly needed for the usual domestic requirements of any individual. Wells have been found to be very favourable sources for the Anopheles stephensi to breed particularly in the southern parts of the city. It has been conspicuously absent in the northern part although Anopheles subpictus (Rossi) and culex are abundantly found breeding in wells in this area.

After the first malaria survey was made in Bombay in 1908 it was recommended that wells should be covered with cement concrete leaving an opening fitted with wire gauze trap doors. The object of the wire gauze was to prevent the entry of mosquitoes in the wells. But time has shown that these trap doors have not served any useful purpose as regards mosquito control since they are always found left open. Concessions for trap doors were granted in those days on account of religious objection to pipe water. A trap door even if kept closed after use would hardly maintain the arrangement in mosquito proof condition which was the main object of providing them. Having been made of wooden frames fixed on hinges they soon became loose or broke and rendered the well non-mosquito-proof. In majority of cases these doors would be intentionally left open during night by some people holding peculiar superstitious views.

To guard against all these abuses stricter measures have been adopted since the last malaria enquiry which was held in 1928. It was recommended that wells should either be filled in or hermetically covered with cement concrete. No trap doors should be allowed in any case.

As one of the most important anti-malarial measures closure or filling of wells would be a boon to the city but to meet with the requirements of certain religious minded section

of people a policy has been adopted to eliminate their number as largely as possible. According to this policy all wells situated in temples or other places of prayer or worship such as Hindu Temples, Parsi Agiaries or Fire Temples and Mahomedan Mosques or Masjids, and in public charitable institutions known as dharamshalas are to be retained open for the use of the public who need well water. Over and above these a few private wells are also to be kept open for the same purpose. In the selection of private wells for being kept open it is stipulated that at least one well will be kept open within a distance of 500 yards. With the exception of such wells and those which will have to be retained in the northern part of the island for the watering of palm trees all other wells in the city have either to be filled with earth or covered with cement concrete.

It is cheaper to cover a well than to fill it up and majority of the owners prefer to do so as in case of emergency the cover can be broken open and reconstructed. If in spite of covering, well water is required to be drawn, the Malaria Department does not object to the installation of a hand or mechanically worked pump, provided the mosquito-proof condition is not disturbed.

There are newly devised hand pumps now on the market in which no leather or rubber parts are used which find ready sale among people who object to the use of these materials in any devise used for drawing water for religious purposes.

Certain section of the public objects to the cement concrete cover as no light and air can pass in the wells although they have been permitted to instal pumps for drawing water. To meet with their requirements they are allowed to fix thick glasses about 1 inch in thickness and copper plates with perforations not bigger than $\frac{1}{16}$th of an inch, in the cement concrete for the entry of light and air respectively. This arrangement has found favour with some people as it provides them with all which their sentiments

demand and at the same time meets with all the requirements of the Malaria Department.

Mosquito breeding has to be controlled in wells which are kept open in the city for purposes mentioned above. Oiling cannot be employed as water is to be used for drinking purposes and clean water is needed for the peformance of religious ceremonies. Whatever measure adopted for mosquito control must therefore be such as to maintain water suitable for these requirements. This is achieved by the effective action of certain fish on mosquito larvæ. Water of wells stocked with larvæcidal fish remains clean and free from mosquito larvæ. In Bombay, the fish ordinarily used for this purpose belongs to the species Anabas scandens and is known locally as khajura. It has been ascertained that one dozen of these fishes are enough for 15 square feet of water surface to produce effective larvicidal results. It is however necessary to observe the results by periodically examining the water for larvæ. As a rule wells stocked with larvicidal fish remain free from mosquito larvæ but if in spite of the presence of fish breeding is found, steps are taken to destroy it by dusting the water with Paris Green mixture. The combined action of fish and Paris Green has been found to be very effective for mosquito control in wells but it is needed only for wells in which there is some vegetation which protects the larvæ from the fish. In wells free from vegetable growth fish alone is sufficiently effective and the combined measure hardly becomes necessary.

PERMANENT BREEDING PLACES IN GARDENS AND COMPOUNDS.

These are fountains, masonry underground tanks or tubs and barrels used for storing water. If these are not scrupulously looked after regularly from anti-mosquito point of view, they become very fruitful sources of mosquito nuisance and consequent malaria danger.

The residences of most of the wealthy class of people have gardens attached to them. Ornamental fountains are to be found in most of these gardens. These fountains are so constructed that they have big circular masonry tanks at the bottom and above in the centre there may be several other basins either of stones or metal. Water spraying from the fountain drops and collects in these basins and the tank. Fountains thus become potential breeding places. Breeding cannot be checked by oiling the water as it will spoil the fountain and the owners will not allow the water to be spoilt by oiling as the water collected in the fountain tanks is invariably used for watering the garden plants.

For controlling mosquitoes in these fountains it is therefore enjoined that the basins should be either filled with cement to disallow collection of water in them or provided with holes to drain away water. Similarly the bottom of the tank is required to be so sloped and drained that it can be completely emptied. Fountains have been allowed to remain on condition that they will be completely emptied once every week and kept dry for at least 24 hours, preferably on the day of the Malaria Overseer's weekly inspection of the place.

The ideal method of watering plants would be by means of a hose pipe which could be attached to a water stand post. But owing to the antiquated methods of the gardeners and the tendency of owners to economise on water charges by utilising the water from the fountains for watering plants the suggestion for using hose pipe has not received much response. Where there are no fountain tanks for storing water, masonry tanks specially constructed for the purpose have been provided and in some cases big wooden tubs are used. These prove to be very common breeding places in gardens if precautions are not observed for efficient control of mosquito breeding. These are filled with water every day and water is pailed out by the gardener for watering, some water is however bound to be left in these. As an anti-mosquito

measure, it is made obligatory on the owners to connect such masonry tanks to drains on their premises and they are required to empty and keep them dry for at least 24 hours once every week on the day of the Malaria Overseer's visit. The wooden tubs have also to be emptied at least once a week or at more frequent intervals if necessary.

These precautionary measures for mosquito control are usually applicable both for private and public gardens, but in the Victoria Gardens which is a botanical and zoological garden in Bombay, certain intricacies in the anti-mosquito measures have to be faced. There are big artificial puddles in which valuable water birds are kept. Anopheles mosquitoes are invariably found breeding in these and sometimes when Anopheles breeding is checked Culex begin to breed. Bearing in mind the presence of birds in these puddles very careful measures have to be devised. Oiling is out of question although it would destroy both Culex and Anopheline larvae, as it would be injurious to the birds. Fish can be of no help as the birds will not let the fish live.

Anopheline mosquito control in these puddles has been successfully effected by the use of Paris Green. Water is dusted with Paris Green mixture by means of a mechanical blower regularly every week and there has not been any poisonous effect on the birds. The regular periodical treatment with Paris Green of these puddles has amply substantiated the prevailing view regarding the non-poisonous effect of this arsenical compound on birds.

Water-closet flush cisterns.—There are two types of flush cisterns. (1) the automatic flushing tank which is usually installed for public latrines or urinals and (2) the pull chain flush tanks for water-closets.

The automatic flushing tanks are made of galvanised tin sheets provided with lids of the same material. The tank is an oblong box and it has been found difficult to keep it in mosquito-proof condition as the lid does not fit tightly and

very often the cisterns are tampered with and the lids are not replaced carefully. This type has now been condemned. Mosquito-proof cast iron automatic flush tanks are now available in the market and whenever the old pattern cisterns are found non-mosquito-proof they are required to be replaced with the new type. As long as the automatic contrivance works and water from the tank is discharged every now and then so long there is no possibility of mosquito breeding in them, but the danger arises when the flush is out of order. The Malaria staff is required to treat with Saponified Cresol water in tanks which are found to be out of order.

The water-closet flushing tanks which have so far been installed in Bombay have not been of mosquito-proof pattern. The cover of such a cistern is not tight fitting and besides there is an open slit in the cover for working the flush. In occupied buildings there is no risk of mosquitoes breeding in the water-closet flushing tanks as the flushes are constantly in use, unless they are not in working order. But in unoccupied buildings there is always a possibility of mosquito breeding in these tanks and also in the water seal of the water-closet pan. Regular inspection of such buildings for examining the water-closets also forms part of the Malaria staff's routine work. At each inspection the water-closet is flushed or if the flush is not found in working order a little Saponified Cresol is added to the water in the tank and in the pan.

The use of these non-mosquito-proof flushing tanks has recently been discontinued and for any new building no such tank is allowed to be installed. Mosquito-proof flushing tanks which have tight fitting cast iron covers without any holes or slits are now obtainable. The installation of such flushes has now been made compulsory for all new buildings.

Roof gutters and terraces :—Some of these are likely to become temporary sources of mosquito breeding during monsoon and therefore all roof gutters and house terraces have to be carefully inspected for any water collections.

Water may collect and remain stagnant in roof gutters due to improper slope of the gutter towards its outlet or due to any obstruction. Some of the house terraces hold rain water in depressions or places which are not properly sloped towards the outlet. Mosquitoes are found breeding in these water collections if they are allowed to remain for a week or so. When such water collections are noticed it is the duty of the Malaria staff to get the water swept off and subsequently to require the owner to take such steps to remedy the defects as to prevent water accumulating anywhere on the terrace.

OVERHEAD SPRINKLER TANKS IN MILLS.

These tanks are installed in mills at heights not less than 100 feet. Even at this height Anopheles stephensi has been found breeding. As an anti-mosquito measure, therefore, these tanks are required to be covered hermetically either with wrought iron plates or cement concrete. Manhole openings are allowed but they are required to be provided with the standard pattern cast iron cover similar to those provided for domestic cisterns. One additional fitting is required for these tanks which is the water level indicator. Different kinds of such indicators have been devised but the one ordinarily in use and which has been approved consists of a float on the water surface which is connected by means of a wire to a lead or iron ball. The wire passes through a hole in the cover of the tank and its other end with the ball passes over a pulley and hangs on a side of the tank. On this side the figures indicating the depth of water in the tank are painted and as the float on the water surface inside the tank rises or falls the ball outside indicates the water level. The hole through which the wire passes is required to be made just enough for the wire to play. If the hole is made in the cement concrete it is likely to become bigger in course of time rendering the arrangement non-mosquito-proof. To obviate this a small iron plate with a hole through which the wire is passed, is fixed in the concrete cover. In the case of wrought

iron covers the hole can be made in one of the plates. In connection with these holes made in the covers for water gauges it is necessary to see that there is no gap or chink surrounding the wire more than $\frac{1}{16}$ of an inch.

The same conditions as in the case of domestic cisterns apply to these tanks for maintaining them in perfectly mosquito-proof condition. They are required to be examined periodically.

Mill ponds.—The other potential breeding places in the mills are the mill ponds. These are invariably found breeding mosquitoes. In most of these Culex mosquitoes breed profusely but it is not unusual to find Anophelines breeding in some of the tanks. In dealing with these potential breeding places in Bombay it is more a mosquito problem than a malaria one, as the malaria carrier Anopheles stephensi has very rarely been found breeding in these ponds.

Oiling is resorted to as anti-mosquito measure for these tanks. Every tank is oiled once every week either by the Malaria Department Staff or by the mill authorities themselves. In cases where the mills have joined the oiling scheme of the Department they are made to pay a certain sum every month.

There may be some technical objections for oiling the water or for using any chemical in such tanks as for instance there has been in one case in Bombay. This is a dyeing mill and the water in the tanks is taken from the Municipal supply. The water is replenished every now and then with the result that the clean water breeds anopheles—fortunately the non-malaria carrier Anopheles subpictus has been invariably found breeding. As no oil or chemical can be used, larvicidal fish has been stocked in the tank to control mosquito breeding, care being taken to see that there is no vegetable growth which would impede the effectiveness of the fish.

Fire buckets.—According to the fire insurance rules buckets are required to be kept full with water. If this water is changed every day there would be no risk from mosquito point of view but as this is not likely to be done these water buckets have often been found breeding mosquitoes. As a precautionary measure the mill authorities are required to keep this water treated with Saponified Cresol. This disinfectant imparts a milky colour to the water and makes it easy for the inspecting staff to see whether the necessary precautions are being taken.

Sand has been recommended as a substitute for water in these buckets for extinguishing fire but it has not met with the approval of the Insurance agencies.

Machinery and scrap iron.—Machinery parts of various kinds, barrels, tubs and scrap iron of any conceivable kind are found stacked in many mill compounds. These are a menace to public health during monsoon as they hold rain water and constitute temporary breeding places for mosquitoes. As a precautionary measure the mill managements are called upon before the rains set in to either remove or to keep all such articles in covered places so as to prevent collection of rain water in them. If in spite of this any articles are found holding water, care is taken either to remove the water or to oil the water every week regularly.

Building works.—During the construction of a building, big or small, several breeding places are temporarily formed. If the work is started during rainy season water accumulates in the foundation trenches or subsoil water may collect in them in dry season. They become breeding sources until they are again filled up. A mortar mill or chunam ghani is an indispensable accompaniment of big construction works. It is also likely to be one of the breeding sources if water is allowed to collect in the circular trench in which the mortar is pounded. There are masonry tanks specially built for storing water and

all kinds of wooden tubs and barrels are also used for various purposes. The commonest use made of these receptacles is for soaking bricks in water before they are used for building.

Cement concrete buildings have in recent years become more popular and are being built on a large scale. In the construction of the floors of these buildings it is necessary to store water on the concrete surface by impounding it with small bunds for the purpose of setting the material. This water is kept stagnant for several days and replenished daily with fresh water. In the absence of any precautionary measures Anopheles stephensi has been invariably found breeding in these water collections.

The procedure followed in the road construction works for consolidating concrete layer is the same as above and mosquitoes of the same variety have not infrequently been found breeding in the water stored for setting.

No sooner a building construction work is started than the Inspector of the ward is required to submit a detailed report to the Officer in charge of the anti-malarial operations. The attention of the owner or building contractor is then drawn to the various breeding sources which may exist or are likely to be created during the progress of the building works and he is called upon to take steps for the prevention of mosquito breeding by either completely emptying all water containers at the end of the day's work and for such other collections of water as are made for setting cement, the use of Saponified Cresol is insisted upon. If mosquito nuisance arises, on failing to comply with the suggested measures, legal action is taken to enforce the requisite preventive measures.

Cellars.—Many newly constructed buildings on Ballard Estates and some old buildings in the town which are occupied by commercial firms have been provided with cellars. Sub-soil water percolating into these cellars constitutes mosquito nuisance. The owners are required to render these water-

tight by means of impermeable material. Some of the cellars have thus been made water-proof during recent years and no water has been found to percolate through the material which has been used for the purpose.

The water in cellars which have not been thus made impervious is required to be treated with Saponified Cresol once every week regularly to prevent mosquito breeding. All cellars which have not been made water-tight have to be inspected by the Malaria staff once every week.

Seepages from water reservoirs.—There are two Municipal water reservoirs in Bombay, one at Malabar Hill and the other at Mazgaon known as Bhandarwada reservoir. Seepage water percolating through the sides of the reservoir if allowed to remain stagnant in any hollows or depressions forms very suitable sources of mosquito breeding. Anopheles stephensi has been found breeding in such seepages. Hollows and depressions in which the water collects may be filled in with earth or the breeding may be destroyed by oiling. It has been found that the best way of dealing with the seepages is to drain away the water. For efficiently draining all the seepages it is necessary to divert them into several small properly cemented channels which could be connected to a bigger one discharging into a storm water drain. Weekly attendance to these seepages from the reservoirs forms part of the anti-malaria crusade work.

Temporary breeding places.—The work of the Malaria Department enormously increases during monsoon due to the formation of numerous temporary breeding places. The most common temporary sources of breeding which call for careful attention of the Malaria Department may be stated here.

(1) *Machinery and scrap iron in Railway yards.*—All kinds of heavy or light machinery, scrap iron and receptacles of various description are found stored in Railway

yards. During the rainy season most of these articles hold water and constitute a source of mosquito nuisance. On the weekly visit of the Malaria staff to these yards steps are taken to empty such receptacles or articles as could be easily overturned. The collections of water in the heavy articles are oiled to prevent or destroy breeding if found.

(2) *Private stores.*—There are a number of dealers in the city who trade in all sorts of empty drums, barrels and tins. These stores if allowed to remain in the disorderly manner in which they are ordinarily kept would become very serious sources of mosquito nuisance due to the collection of rain water in the various receptacles. With a view to prevent this the owners of such stores are served with notices, some time before the onset of rains, either to remove all the receptacles or to keep them in covered places in such a way as to disallow any collection of water. It is not possible in some of the cases to remove these articles but the receptacles are protected from rain by erecting temporary sheds.

(3) *Municipal Road Department stores and other public stores.*—In several parts of the city there are Municipal Road branch stores. In these stores a large number of barrels containing coal tar used in road construction and empty barrels are stored. It is generally insisted that all the empty barrels should be kept overturned to prevent collection of rain water but in spite of this measure there is still a risk of water collecting in a small space at the bottom which is formed by the circular rim of the barrel. To avoid water collection in this, it is required to be filled with sand which is available in the stores. The barrels which are full are also likely to be sources of mosquito breeding on account of the same reason and they are therefore required to be kept on their sides. If any water collects, in spite of these precautions, and becomes a source of mosquito breeding, the overseer in his weekly crusade destroys the larvæ by oiling the water.

The other public stores contain barrels, tubs, drums and tins. The same precautions as above have to be observed in the case of these stores.

Odd receptacles in private premises.—It is not uncommon to find several kinds of disused articles being thrown about in the vicinity of dwellings. These by holding water are likely to afford good breeding material for mosquitoes. During the routine mosquito crusade work the malaria staff has to see for odd receptacles in every place they visit. If the articles are such as could be easily handled by them, they are overturned so as to prevent collection of rain water. If the receptacles are of no value they are collected and removed. If however they are big the owners are called upon to remove them or to place them in such a way as to disallow water collections.

Depressions and low-lying lands.—These become sources of mosquito breeding during monsoon when rain water collects and remains stagnant sufficiently long for mosquitoes to breed. The variety of breeding in these differs in some small temporary depressions in the southern part of the city. Anopheles stephensi is found breeding, whereas in most of the low-lying lands which remain under water during the whole of monsoon, in the northern part, the species found breeding is invariably Anopheles subpictus.

Whenever mosquito breeding is detected during the routine crusade work steps are taken immediately to destroy the larvæ by oiling. The owners of lands where such depressions are found are called upon to fill in the depressions with good earth so as to prevent any accumulation of water.

As regards the low-lying lands in the northern part of the city which remain under water and some of which are used for grass cultivation, measures are adopted for mosquito control by the use of Paris Green. During the rainy season these are regularly sprayed with Paris Green mixture once every

week. At the end of monsoon whatever water remains, is pumped out into neighbouring storm-water drains.

Organisation and work of Malaria Department.—For Municipal administration Bombay has been divided into seven wards. For anti-malarial work, the staff is engaged according to the requirements of each of these wards.

At the head of the department there is a Malaria Officer who is responsible to the Executive Health Officer for all anti-malaria work. The supervising and inspecting staff of the department consists of eight qualified Malaria Inspectors, eighty overseers, seven mukadams, two hundred coolies, a mason and a carpenter. The Malaria Inspectors possess a registrable medical qualification and some of them have been trained in Malaria work. There is one Inspector in charge of each ward and an additional one who looks after anti-malarial work in mills in the northern part of the island. The Inspectors have their offices in their respective wards. Each Inspector has under him a certain number of overseers and each overseer is given two coolies. The number of overseers varies in different wards according to the extent of the ward and the nature of the work.

The duty of the Malaria Inspector is to supervise the work of the overseer and to control the whole staff under him. He is required to attend to all the mosquito complaints and to report on all matters relating to mosquito control and prevention of malaria in his ward.

For the work of the overseers each ward has been divided into several sections and one overseer is placed in charge of each section. These sections are again sub-divided into six blocks. An overseer is required to inspect all water containers and other potential breeding places in each of these blocks on an appointed day in a week. In this way he is able to attend to all water containers and other potential breeding places in his section during the course of a week.

Each overseer has to maintain a mosquito record book. In this book a careful record of all the water containers and other potential breeding places at each and every place or premises in the section of the overseer is kept. He is required to make an entry into this book as to the condition of these breeding places on the day he visits the place. Defects have to be noted and reported. If any mosquito breeding is detected he has to take steps to destroy it immediately and to report it. At the same time a note of breeding is made in the book. The overseers submit all their reports to the Head Malaria Office through their Malaria Inspectors.

As regards the duties of the coolies they are not required to do any work independently. Two coolies accompany an overseer for his daily routine inspections and assist him in finding out mosquito breeding, collecting larvæ samples and in destroying the breeding with suitable larvicides or other measures.

The mukadams have to attend to several things such as the preparation of oil mixture, Paris Green mixture, stocking of wells with fish, etc. The mason and carpenter attend to such minor defects in the water containers or wells as could be easily remedied without calling upon the owners to do so.

The Malaria Officer is responsible for the working of the whole department. He directs the policy of the department as regards all anti-malarial measures. He is assisted by a clerical staff.

There is a small laboratory attached to the Malaria Office where the work done is mostly identification of anopheline larvæ and examination of blood slides for malaria parasites.

Whenever anopheles breeding is detected anywhere in the daily routine inspection of the overseers, the Malaria Inspectors are required to send samples of these larvæ to the laboratory with full particulars as regards their source. The larvæ

are carefully examined and whenever a sample is identified as that of an Anopheles stephensi, intimation is immediately given to the Malaria Inspector of the ward of the result of identification and he is directed to take stringent measures to prevent or stop the breeding. The aim of the malaria department is to direct all its activities in this way towards the eradication of the malaria carrying mosquito of Bombay, *i.e.*, the Anopheles stephensi without in any way ignoring the annoyance caused by all other kinds of mosquitoes. In Bombay the war is therefore against mosquitoes in general but against Anopheles stephensi in particular.

The following species of anopheles mosquitoes are found in Bombay :—

Anopheles subpictus (rossi).
" stephensi.
" vagus.
" barbirostris.
" fuliginosis.
" culicifacies.

CHAPTER X.

Disinfection.

Disinfectants are the agents which destroy the germs of disease either free or in the infective material conveying those germs. An *antiseptic,* on the other hand, is a substance which merely restrains the growth of organisms and prevents animal and vegetable matters from decomposing. *Deodorants,* which are frequently confused with disinfectants, are substances which either serve to cloak offensive smells by their own odour or destroy them by oxidation.

Complete disinfection or sterilization is that in which both bacteria and their spores are destroyed, and *incomplete* is that in which the bacteria only are killed. In Public Health work, it is not enough to destroy the organisms only which cause the diseases but the agents which convey them, *e.g.*, lice, bugs, fleas, rats, etc., must be destroyed as well. To this the term "Disinfestation" is applied.

In practice, disinfection is accomplished by the agency of heat and chemical substances but there are certain accessories which play an important part and may properly be considered here, *viz.*, mechanical cleansing, light and desiccation.

Mechanical cleansing.—Cleansing with soap and water unquestionably removes many organisms and the scrubbing of floors, furniture and wood-work is a necessary adjunct to chemical disinfection. Again, in disinfecting a room lately occupied by a phthisical patient, the removal of dust from the walls by means of dough, as advocated by Esmarch, affords a valuable safeguard to the workman employed; as the dust is entangled in the dough instead of being scattered about. The dough is subsequently destroyed by fire.

Light is a most important factor in keeping down the number of bacteria, as it has a deleterious action on them in their vegetative form and to a less extent in their spore form.

The ultra-violet rays are much more powerful than the infra-red. The effect is increased by the presence of air and moisture and is probably due to a process of oxidation, varying according to the duration of exposure, the intensity of the light and the variety of organisms present.

Desiccation or drying may kill many of the non-sporing organisms, *e.g.*, Staphylo-cocci and Strepto-cocci, Typhoid bacilli, etc., but the spores of spore-bearing organisms are not destroyed. They resist drying for an indefinite period and really become more difficult to kill by other means. The Anthrax and Subtilis bacilli are examples of this latter class.

Valuable though these accessories are, public authorities have to take more active measures, and these include the use of heat in one form or another or of chemical substances.

Objects of disinfection.—It may be necessary to employ agents for the destruction of known germs of disease, or for the destruction of the infective material of other diseases, the causative agent of which has not yet been isolated, but which is in all probability organismal in nature. On the other hand, the main object may be not so much the destruction of the germ itself directly, as the destruction of the carrier of the germ. Modern research has clearly demonstrated the part played by certain insects in the spread of communicable diseases, and it may be against such carriers more particularly, that our efforts should be directed, *e.g.*, fleas in Plague, certain varieties of Anopheles mosquitoes in Malaria, Aëdes (Stegomyia mosquitoes) in Yellow Fever, flies in the spread of Cholera, Typhoid and intestinal diseases such as Diarrhœa, etc. Again, the destruction of organisms may be necessary for the preservation of food materials, *e.g.*, sterilization of food in the process of tinning such materials. It cannot be too clearly understood by the Inspector that disinfection is not meant to replace cleanliness and that the wholesale sprinkling of foul surfaces and objects with disinfectant fluids and powders is a procedure both wasteful and useless. Preventive medicine

demonstrates more and more the value of cleanliness and to cloak the smell of foul and decomposing matter with a powerful deodorant is not only a waste of time and material but is indicative of an entire absence of knowledge of the true use of such agents, or of gross negligence. This matter is referred to here because one so often sees such practices adopted, and for this sanitary authorities are themselves much to blame, owing to the indiscriminate distribution of so-called disinfectants to householders without first explaining the imperative necessity of removing the source of nuisance before applying deodorants or disinfectants.

DISINFECTION BY HEAT.

Heat as a disinfectant may be employed in the form of dry or moist heat.

Incineration.—This, though complete disinfection, is of limited value in practice. Discharges from patients suffering from infectious diseases may be burnt after being mixed with saw-dust or some other combustible material. Articles of little value like rags or soiled mattresses may also be destroyed by burning. Plague infected huts may also be similarly destroyed as it is so difficult to disinfect them and destroy the fleas by other methods.

Dry heat.—As dry, hot air depends upon conduction and only very slightly upon convection for its action, it cannot penetrate very far into bulky articles. Disinfection by dry heat has been almost universally superseded by disinfection by moist heat on account of the disadvantages associated with the former, which may be summarised as follows. The duration of exposure and degree of temperature attainable are limited by the tendency to scorch. Its penetrative power is small and articles, which on the surface are scorched, may, in the interior, never have been heated to a proper temperature. It is slow in action and its germicidal power is less than that of steam at any given temperature. Moreover, some parts of

the hot air chamber are hotter than others and consequently infected articles are acted upon unequally. Fusible substances like glue and wax are melted and many articles become brittle as a result of overdrying.

Moist Heat (1) *Boiling*:—Infected textiles may be disinfected by this method. The non-sporing bacteria are killed at once, while the sporulating organisms can be destroyed by boiling for about one hour. If the articles are stained with albuminous matters as in blood and fæces, boiling will fix the stain. Hence they should be previously soaked in cold water and, if necessary, scrubbed with a little soap.

(2) Steam is the agent used by most public authorities at the present time for the disinfection of bedding, clothing, etc. It enables a higher temperature to be reached without danger to the articles, and moreover it has a much greater penetrating power than dry heat, and is more rapid. The steam may be supplied to the disinfector either from an existing boiler used for some other purpose, or from a special separate boiler used only for the disinfector, or lastly, the jacket of the disinfector may serve as a boiler, examples of which will be referred to at a later stage.

Steam at a given pressure is not equally efficient, whether it is used as *saturated* steam or *super-heated* steam. *Saturated steam* is steam at a temperature very slightly above that at which it has been generated and therefore condensing on being slightly cooled. *Super-heated steam* is steam, at a temperature at least several degrees above that at which it was generated and so resembling gases in that it requires to be compressed, or cooled considerably, before passing into the liquid state. It is a bad conductor of heat, resembling air in that respect. Saturated steam, on the other hand, can easily convey heat and, on coming in contact with cold objects, condenses and in doing so imparts its latent heat to those objects and shrinks very considerably in volume ($\frac{1}{1600}$). A vacuum is thus produced to fill which more steam is drawn

in resulting in the further penetration of the article layer by layer till the centre of the mass is reached. When the temperature of the object is raised sufficiently, the water thus condensed is vaporized again. When this takes place in connection with a pillow or other porous article, successive layers become heated in turn, provided always that the contained air is allowed to escape : otherwise, if allowed to remain, it interferes with the penetrative power of the steam and therefore with rapid heating.

Super-heated steam is saturated steam which, after having been removed from the presence of water, has been surcharged with heat. It cannot endure in the presence of water, as the latter will absorb the surplus or super-heat until the steam reverts to the saturated condition.

Defined in another way, saturated steam is fully evaporated water. It is perfectly dry and contains, in a given volume and at a given temperature, the maximum weight of evaporated water and incorporated heat. In the boiler it has the same temperature and pressure as the water from which it is produced.

Steam either in the saturated or the super-heated condition may be confined, or it may be in motion, *i.e.*, current steam. Moreover, it may be used at atmospheric or low pressure or at high pressure. The term 'low pressure' as applied to disinfectors means steam given off at boiling-point and atmospheric pressure. Similarly, 'high pressure' means only a pressure of 10 to 15 pounds, representing at ten pounds a temperature of 115° Centigrade. Very many experiments have been made by different observers to test the relative efficiency of various types of disinfectors. Esmarch using Anthrax spores and current super-heated steam concluded that current steam should never be super-heated. Such steam cannot condense until it has been cooled to the saturation-point, and consequently it can only act as dry, hot air by conduction. The use of super-heated steam means a longer exposure and consequently a greater consumption of

fuel and more liability to injure the articles, with less reliability as to disinfection.

Air in the interstices of the clothing greatly interferes with the penetration of the steam. This difficulty can be overcome in various ways. One method is to pass a rapid current of steam through the chamber, which must be provided with a sufficiently large outlet and means whereby steam can be generated rapidly. Another method is to provide a vacuum or exhaust pump to extract the air prior to disinfection, and a third way is, from time to time, to intermit the pressure within the chamber. The sudden reduction of pressure causes an expansion of the steam in the interstices of the material under treatment, and vaporization of the moisture contained therein which displaces the air in the articles.

Much has been written by the supporters of the two different systems, *viz.*, current steam and saturated steam under pressure. The former is cheap, the apparatus is simpler and is easy to work. For many, if not all, practical purposes the prolonged exposure of infected articles to a rapid current of steam, especially if that steam is kept a few degrees above condensation-point, produces disinfection and, if prior to the introduction of the current steam, a vacuum or partial vacuum is produced, the penetrative power of the steam is increased and its action is more rapid and powerful. Current steam is eminently suited for small installations and where skilled labour is not available. The opponents of this system object to it on the ground that it is difficult to control the rate of the current and the rate at which the steam is generated and they claim that with saturated steam under pressure there is a constant and efficient condition under control and that in practice it is easier to expel air by this method than by current steam. Steam under pressure, however, requires a much heavier and more costly apparatus.

Whatever type is used, for practical purposes, it is necessary that the chamber be of a suitable size, the most

useful being one which is about 6 to 7 feet in length and 4 to 5 feet in depth.

The rapidity of the penetration of heat into articles is ascertained by placing within them a thermometer, which on registering the required temperature rings a bell by reason of the mercury completing the circuit of an electric current from a battery. The efficiency of the provision for drying the articles is gauged by the amount of moisture remaining in them after removal from the stove, as calculated by the increase in weight of the articles. The maximum temperature reached in the stove and the uniform distribution of the heat may be tested by means of recently standardised maximum thermometers wrapped up in blankets and exposed in the stove ; and the pressure within the stove can be ascertained at any time by the pressure-gauge.

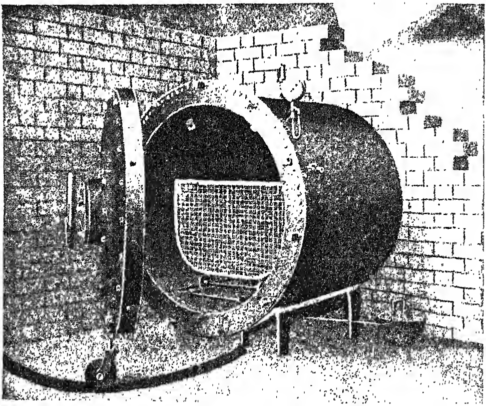
Of the numerous types in use in the different parts of the world, a few of the better known ones may be referred to here.

(1) The Equifex Disinfector uses saturated steam under pressure. It has no jacket but has the usual two doors which are provided with wheels, and floor rails to facilitate opening and closing, and also rails on which runs a wheeled cradle for the clothing. The steam is derived from a boiler which is quite distinct from the apparatus itself. Several sizes and types are constructed. One type, which is used both by the Bombay Municipality and the Bombay Port Health Authorities, works with a pressure of from 7 to 10 pounds per square inch. Another type works at from 2 to 5 lbs. pressure. Means for producing a vacuum in the chamber are provided and there is a coil of pipes containing steam running through the chamber ; these coils assist drying after disinfection and also prevent undue condensation of steam. At intervals the pressure of steam in intermitted. In recent patterns there is a recording gauge, which traces on a chart the temperature in the chamber throughout the whole period of disinfection thus serving as a check on the attendant in charge. The exposure allowed is usually about 20 minutes. The cylinder is covered outside with a non-conducting composition and wood to reduce loss of heat by radiation and furnished with separate doors for infected and disinfected articles respectively.

(2) The Washington Lyon is oval in section. It opens at both ends and has a jacket surrounding the wall of the disinfecting chamber, between

which there is a space of 3 to 4 inches. A vacuum-producing apparatus is provided. It has a separate boiler, and the pressure at which it works is between 10 to 20 lbs. per square inch. As at present used, the pressure in the jacket is somewhat lower than that in the chamber, the main use of the former being to heat the latter before steam is turned into it. The doors are non-jacketed. Before commencing disinfection proper, a current of steam should be allowed to pass through the chamber. 10 or 20 minutes suffice for the penetration of even bulky articles ; when disinfection is complete, the steam is allowed to escape from the chamber ; the door is opened and the articles removed.

If it is desired to dry the articles thoroughly, they may be exposed to the heat of the steam in the jacket.

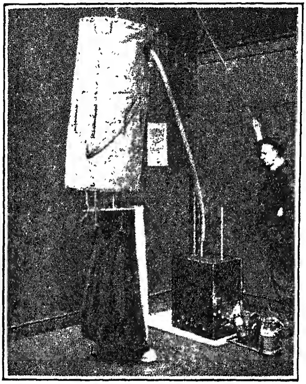


NEW TYPE THRESH CURRENT STEAM DISINFECTOR.

(3) Thresh's Low Pressure Disinfector consists of a chamber surrounded by a jacket, which contains a solution of calcium chloride. The jacket acts as a boiler, the furnace being situated underneath. The salt present raises the temperature at which the water boils and the steam rises at about a temperature of 106°C. without applying extra pressure. It is a low pressure current steam apparatus, the steam being slightly superheated. The process is finished in about an hour. The apparatus is simple, cheap and efficient.

As the water of the boiling solution evaporates, an equivalent amount is automatically introduced from a small cistern with a ball valve arrangement.

(4) The sack disinfector of Colonel Lelean is convenient and portable. A steam-proof sack, filled up with the fabrics to be disinfected, is hung up and the steam is led into it from above from an oil-fired boiler. The live steam fills up the sack and disinfects the articles efficiently.



*SACK DISINFECTOR.

A DISINFECTING STATION should comprise of the following:—

(1) Two rooms completely separated from each other by a wall into which the stove is built, so that it communicates with both rooms. The infected articles are brought into one room and placed in the stove, and after disinfection they are removed

* *Block supplied by:* Indestro Trading Co., Engineers, Tamarind House, Fort, Bombay.

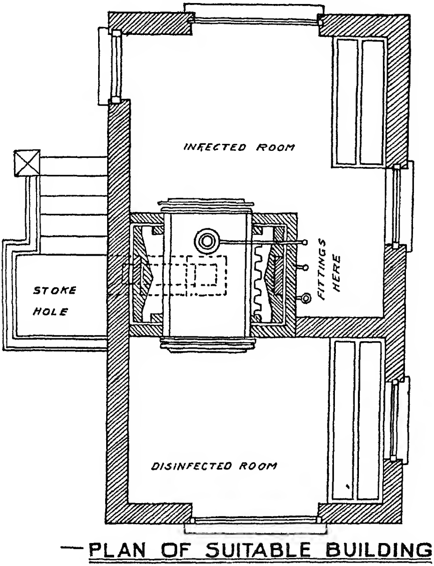
from the other end of the stove, which opens into the non-infected room. No infectious material must be allowed to enter the non-infected room, and there should be no direct means of communication between it and the infected room. The floors and walls of both rooms should be made of some smooth and non-porous material, which can be readily and efficiently cleansed by water; an exceptionally good provision should be made for ventilation and light. If good ventilation is not provided, the rooms become very hot in the summer time, and it is a good plan, in order to reduce the heat and to protect the articles from dust and smoke, to arrange that the stoke-hole and coal-store are outside the compartments when the furnace is immediately under the disinfecting oven; and even when the boiler is separate, the stoke-hole and coal-store should be placed in a small compartment, shut off from the working rooms.

(2) An incinerator and destructor provided with a small second fire to cremate the products of imperfect combustion before they pass up the flue.

(3) Separate sheds for (*a*) vans employed to bring in infected articles, and (*b*) those employed to return the disinfected articles.

(4) A laundry and bath-room should also form part of a disinfecting station, and a charge may be made for any laundry work undertaken after the disinfection of infected articles.

The Disinfecting Station proper.—The walls should be lined with glazed brick or tiles, carefully jointed, or with some other hard, smooth and non-porous material; and there should be as few angles as possible to harbour dirt. The floors should be laid in concrete, grouted over to a smooth



DISINFECTING STATION.

surface with cement, and with ample provision for drainage. The rooms for infected and disinfected articles, respectively, should be so arranged that direct communication is impossible and the doors of these rooms should be placed at the extreme ends of the building.

Collection and delivery of articles.—Separate vans should be used for the infected and clean articles, and these should have distinctive colourings ; as by picking out with red the infected van, and the van delivering the clean load with white. They

should be zinc-lined, and constructed internally so as easily to be cleaned. The vanmen should have books with duplicate lists of the articles removed, which lists should be initialled by the owner on collection and after delivery.

The system of collecting the smaller articles in canvas bags, which can be put direct into the oven after opening the mouth is generally adopted. By this arrangement, the risk of articles belonging to different premises being mixed at the station is almost removed, but separate parcels must always be made of articles which are damaged by steam disinfection. It is a good plan to place coloured fabrics in bags separate from the white articles; and if each article is carefully folded up and packed in the bag, the articles are not so badly creased as is otherwise often the case.

DISINFECTION BY CHEMICAL SUBSTANCES.

Chemical substances are most usually employed in either a gaseous or a liquid state. They may act on organisms in three different ways:—(1) by attenuation, the organism losing its pathogenic action, *e.g.*, Anthrax bacilli immersed in a solution of carbolic acid of a strength of 1 in 1,000; (2) by inhibition, *i.e.*, the organism is unable to grow or multiply in the presence of the chemical, the removal of which, however, enables growth to proceed; and (3) by killing the organism outright, *i.e.*, exercising a true germicidal action.

An ideal disinfectant should possess the following properties. It should be cheap, of constant composition, readily soluble in water, easy of manipulation and certain in action, and it should be able to act even in the presence of organic matter, *e.g.*, urine and fæces. It should be non-poisonous, non-corrosive, non-bleaching, and non-injurious to wood, linen, paper and metal.

Disinfectants vary widely in their capacity to destroy bacteria. It is necessary for comparing their relative strengths at that standard should be set down and the strength of the

different disinfectants should be compared in relation to this standard. Rideal and Walker proposed that carbolic acid should be taken as the standard disinfectant, and the germ against which the power of the disinfectant is to be tested should be B. Typhosus. The disinfectant, the strength of which is to be determined, and carbolic acid are both allowed to act separately in different dilutions upon the test organism for a definite period and the highest dilutions of the disinfectant and carbolic acid which kill the organism are noted. The dilution of the disinfectant divided by the dilution of the carbolic acid gives the "carbolic acid coefficient." If a disinfectant has a coefficient of 20, it means that it is twenty times stronger than the same strength of carbolic acid. The results of this method are not useful in practice because here the disinfectant has to act in presence of organic matter which this method does not take into consideration.

The best method at present is the one followed by the British Admiralty. Here the germicidal value of the substance is determined in the presence of a definite amount of organic matter consisting of gelatine and finely ground rice starch. The disinfectant is diluted with sterile artificial sea-water and the dilution is allowed to stand for 20 hours. At the end of this period a portion is removed from the middle depths for test purposes. The carbolic acid is also dissolved in artificial sea-water.

Disinfection, in general, presents many difficulties in this country. In a very large number of cases gaseous disinfectants are precluded from use, owing to the structural arrangements of the houses. The difficulties of making the poorer class residences even comparatively air-tight are almost insuperable. The walls and roofs are not even water-tight, and in many instances rat-runs communicating with the exterior are of common occurrence. Then, again, the value of many liquid disinfectants is negatived, owing to the prevalent custom of having earthen floors which are periodically smeared with cowdung. The presence of so much organic matter largely

interferes with the action of disinfectants. In the better class houses, however, these conditions do not obtain and for that reason it is proposed to describe certain disinfectants, largely used in the Western hemisphere, as there is no reason why *they should not be used with the same amount of success in* this class of dwelling.

The consideration of the particular disinfectant to be used on any given occasion largely depends on the nature of the disease and its mode of spread. This is necessitated because some disinfectants, which may have a rapidly fatal effect on bacteria, may entirely fail to kill fleas or bugs, etc., and obviously therefore, if a disease is spread by the latter agency, some disinfectant which combines a pulicidal and a bactericidal action is indicated. For example, Capt. Gloster, I.M.S., has shown that an acid solution of corrosive sublimate even in the strength of 1 in 500 failed to kill fleas after an exposure of ten minutes. Perchloride of mercury is an excellent disinfectant after many diseases, but it is obviously not indicated in a disease such as Plague which is spread largely by fleas. Then, again, Clayton gas, which has such an excellent effect in ships, has been shown to be more or less ineffectual in the typical Indian poorer class dwellings, by reason of the impossibility of making them anything approaching air-tight. It is imperative, therefore, that the responsible authority should select a disinfectant with due regard to local conditions: in some cases a gaseous one can be used, in others it is contra-indicated; further, in certain instances the ordinary well-known liquid disinfectants can be used, whereas in other cases a pulicidal and bactericidal agent is necessary, *e.g.*, in Plague, Remittent Fever, etc. With this reservation we may pass on to the more common gaseous disinfectants and their method of use; these include sulphur dioxide, formaldehyde, chlorine and HCN gas.

Sulphur Dioxide.

This gas can be generated by burning sulphur, either in the form of a powder or in rolls, cones or candles. Cylinders

containing the gas in a compressed form are available in the market, thus reducing the risk from fire. Another method of generating the gas is by burning carbon bisulphide in a lamp. Comparatively recently, an invention known as the *Clayton* gas apparatus has been introduced, which forces the gas into the room to be disinfected and thereby brings about a greater concentration and diffusion of the disinfectant than in the older methods.

Before using any gaseous disinfectant, it is necessary to close all openings, and crevices. All windows, doors and fireplaces, if present, must be closed with gummed paper, and when all possible sources of ventilation have been sealed except the exit from the room, the walls and floor should be moistened with water, as the gas has a more powerful action when moist, and finally, having started the operation, the exit should be sealed. When rolls or powdered sulphur is used, the quantity allowed should be 2-3 pounds for every 1,000 cubic feet of air space. It should be placed in a fire-proof receptacle over water and to aid its ignition, alcohol in small quantities may be poured over it. If cones or candles are used, the number required will depend on the amount of sulphur in each. At the end of about 8 to 10 hours, the room may be entered into and the doors and windows opened wide.

Sulphur dioxide acts as a powerful reducing agent, uniting with the oxygen of many substances to form sulphuric acid; on the other hand, it may occasionally give up oxygen. As a disinfector and destroyer of rats, Klein and others have shown that this gas can be quite as powerful germicidally as formalin.

The Clayton Disinfecting Company have placed a series of machines on the market. These machines can be classed under two heads, *viz.*, (1) High Strength Gas Machines and (2) Dilute Gas Machines. Disinfection by the former is carried out by converting a part of the atmosphere in a room into a gas containing from 12% to 18% of SO_2

and allowing this to mix with the rest of the air in the room. This strength is suitable for hospital wards, rooms and empty holds of ships, but for holds filled with cargo or for warehouses closely packed with merchandise, the Dilute Gas Machine is preferable. This will rapidly convert all the air in a room into a gas containing 3% SO_2. In this system, the air in the compartment undergoing disinfection is extracted and, as it is drawn through the machine, becomes converted into a disinfecting gas at a high temperature by passing over burning sulphur in a specially constructed generator. It is then cooled and forced by pressure back into the compartment. Delivery and suction operations, which are produced by a powerful blower, proceed simultaneously and the volume of air withdrawn is equal to the volume of disinfecting gas delivered into the chamber; so, if any leakage occurs, it is only due to diffusion. The room must be properly closed by pasting up doors, windows, fireplace, etc.

The advantages claimed for the machine are :—

(1) The heat from the combustion of the sulphur is not set free in the room and consequently, damage due to condensation of water vapour is eliminated, *e.g.*, discoloration.

(2) The room can be charged with gas for as long as desired at a given strength.

Certain types of machines (*e.g.*, A & B) can be employed for extinguishing fires in closed compartments, *e.g.*, ship-holds. Experiments were carried out for the Local Government Board in 1905-6 by Mr. J. Wade to determine the efficiency of Clayton gas in disinfecting cargo in the holds of ships. For this purpose a model ship's hold, stowed with a general cargo, was used; arrangements were made to enable samples of gas to be drawn from any part for analysis, whilst rats and bacterial cultures were inserted to demonstrate the action of the gas. Cultures, dried on paper and enclosed

in glass tubes, as well as cultures planted in agar, were used and over 1,100 tests of gas were made.

A summary of the results is given below :—

Rats and insects would be destroyed in less than two hours by the uniform diffusion of at most 0.5 per cent. of sulphur dioxide. This condition is easily and quickly realised in cabins and empty holds, and in the space around the cargo in a loaded hold; but, owing to the extensive absorption of this gas, air containing 3 per cent. of it must be circulated around the cargo for 8 to 12 hours to ensure adequate penetration.

Pathogenic bacteria in exposed places would also be destroyed by the above treatment, and if the hold be closed for a like period afterwards, sufficient penetration would have taken place to ensure the disinfection of all those parts of the interior of the cargo in which these bacteria are likely to be present. Complete penetration can in extreme cases be secured by repeating the fumigation without opening the hatches.

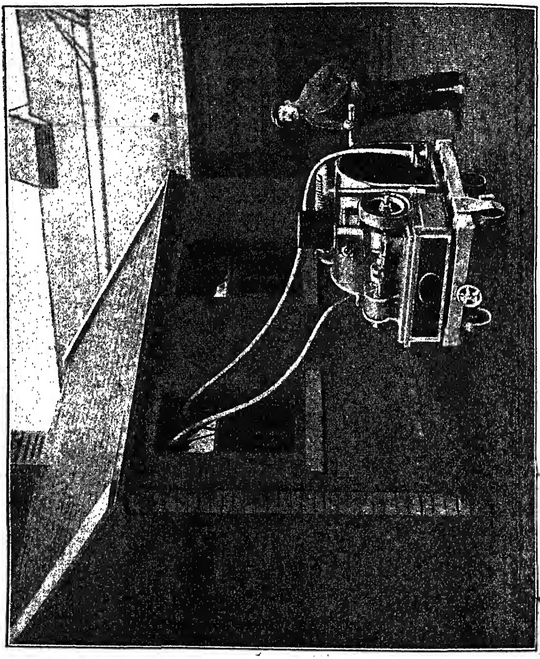
Textile fibres and fabrics, metals and furniture are not affected by sulphur dioxide, but are liable to injury by the accompanying sulphuric acid, when the gas is produced by burning sulphur, unless they are protected by means of a suitable covering. Jute in bales is not affected in any case.

Moist food stuffs, such as fruit, vegetables and fresh meat, are uneatable after exposure to sulphur dioxide, and wheat in bags is rendered useless for bread-making; but owing to the slowness of penetration, wheat in bulk is not seriously affected. Barley and maize are practically unaffected by fumigation with sulphur dioxide.

The gas evolved appears to consist mainly of the residual nitrogen of the air and a small amount of unconsumed oxygen with sulphurous acid in varying amounts up to 15% and a considerable amount of sulphuric acid in suspension, the presence of which makes the mixture white and opaque.

In various experiments in ships, it has been found that when the hold was empty, Plague and Cholera germs were destroyed after a few hours' exposure to an atmosphere containing about 5% of SO_2. Rats were readily killed in two hours, so also fleas and cockroaches with a uniform diffusion of not more than 0.5% of SO_2 through the hold of the ship. The duration of exposure proved to be of more

importance than the degree of concentration of the gas. With a cargo in the hold, the results were somewhat different. The penetrating power of the gas was found to be very gradual more particularly in the case of woollen and other fabrics (not cotton) done up in tight bales. This is due to the pro-



CLAYTON DISINFECTOR.

perty which the fabrics have of absorbing the gas; this absorption takes place in the outer layers of the bales. Wool was found to absorb as much as ten times, and jute at least four times its own volume of the gas. Similar absorptive action was shown by grain and other food stuffs and in the case of flour, the amount of sulphurous acid retained made the flour useless for baking. With a hold full of cargo, it is probable that all germs and all rats and fleas cannot be destroyed. It has been found that, if it is desirable or necessary to disinfect a ship before discharge of cargo, a small proportion of producer gas* (say 10%) should be added to the Clayton gas. The machine drives the sulphur fumes into the lower part of the hold and extracts air from the upper.

In a modern city, composed of well-constructed houses, one can readily understand that these machines can and do perform their work satisfactorily, due to the fact that the rooms can be rendered approximately air-tight, but in the ordinary lower class Indian dwellings such a necessary condition is impossible of attainment, and in Indian villages the great majority of the houses have walls made of bamboo laths and mud or of kerosine oil tins. Moreover, rat-runs or burrows abound and to make such a dwelling rat-proof prior to disinfection is obviously hopeless.

Experiments carried out at the Haffkine Institute would appear to show that rats can readily be killed with Clayton gas, when they are confined in an open room but, if they are allowed to move about freely, some may escape before the concentration of the gas becomes strong enough to overcome them; moreover, certain types of burrows may afford shelter to the rats which thus may escape destruction.

In the Presidency towns and many cities of India, where numerous well-constructed modern houses exist, this method of disinfection can readily be carried out.

*Producer gas is generated by blowing a current of air into a producer in which coke is burned and consists of CO (8%), N. (about 70%) and CO_2.

Formaldehyde.

The germicidal action of this gas has been clearly demonstrated and many devices have been suggested for its use.

(1) *Trillat's Autoclave.*—The apparatus is worked from outside the room which it is desired to disinfect, the gas being introduced by means of a tube or nozzle. The autoclave is charged with a mixture of formalin glycerine, calcium chloride and water (Formochloral). From ½ to 1 litre of Formochloral should be used for a room of 1,000 c. feet, a little extra quantity being used to guard against danger from drying up. Heat is then applied and the pressure raised to 50 or 60 lbs.; the cock is then opened and the ejection of gas begins and continues until the pressure falls to 20 lbs., when the pressure is again raised and the process repeated so long as vapour continues to rise or escape from the nozzle of the autoclave.

(2) *Lingner's Apparatus* comprises of a central receiver which is charged with formalin, glycerine and water (Glyco-formalin); surrounding this is a ring boiler containing water, and this is heated by means of methylated spirit contained in a heating ring underneath the boiler. When the water in the ring begins to boil, the steam passes through a pipe into a central receiver, and the combined steam and formalin are conveyed by means of four nozzles into the atmosphere of the room in the form of a fine spray. Bacteriological tests with this apparatus have proved satisfactory in the highest degree. 4 lbs. should be vaporised for 1,000 c. feet of space.

(3) *Schering's method.*—Tablets of paraformaldehyde are volatilised by burning them over methylated spirit in a patent lamp. The tablets weigh one gramme each. In Germany the Aesculap lamp is largely used for the purpose; in England the Alformant lamp, and more recently the Hydro-formant lamp has been devised to yield more moisture than the other patterns. By this latter lamp, water is converted into steam at the same time as the tablets into gas. For every 1,000 cubic feet of air space, twenty-five tablets should be burned.

(4) *The Potassium Permanganate—Formalin Process.*—In this method a solution of formalin is poured on to crystals of permanganate, resulting in the very rapid evolution of gas, which has been shown by Professor R. H. Firth to consist of formaldehyde, water vapour, carbon dioxide and traces of formic acid. For a space of 1,000 cubic feet, about five ounces of permanganate and half a pint of formalin are required. The walls of the rooms should be first damped and the room sprayed with water.

Mr. Clintic, experimenting in the disinfection of railway carriages with formaldehyde, arrived at the conclusion that very little formaldehyde was produced at temperatures below 60° Fahr. owing to polymerisation of the gas. A large quantity of gas assists penetration as do a high tem-

perature and humidity, but even then, as its penetrative power is so little, it should not be used for articles requiring a high degree of penetration. For simplicity and rapidity he found that the formalin permanganate process was the most efficient and more fatal to the Tubercle bacilli than any other method. He remarks, however, that the presence of water is unnecessary. Tubercle and Coli communis, Diphtheria and Typhoid bacilli and Bacillus subtilis were all killed.

CHLORINE.

Chlorine is a gas extensively used for disinfection purposes. It is a heavy, very irritant gas, which destroys organic matter, bleaches organic pigments and destroys odours. It can be generated in many ways :—

(1) By heating a mixture of sodium chloride 8 parts, manganese dioxide 2 parts, sulphuric acid 2 parts and water 2 parts, per thousand cubic feet of air space.

(2) By acting on manganese dioxide with hydrochloric acid.

(3) By mixing bleaching powder and strong sulphuric acid in the proportion of $1\frac{1}{2}$ pounds of the former to 6 ounces of the latter for each 1,000 cubic feet of air space. The reaction which follows results in the formation of calcium sulphate and hydrochloric and hypochlorous acid. These two latter interact and form chlorine and water. The reaction can be represented thus—

$$CaCl_2O_2 + H_2SO_4 = CaSO_4 + 2HClO.$$
$$CaCl_2 + H_2SO_4 = CaSO_4 + 2HCl.$$
$$HCl + HClO = H_2O + Cl_2.$$

The acid acts at first only on the hypochlorite giving a sulphate and hypochlorous acid but, if enough be added, the chloride also is attacked giving sulphate and hydrochloric acid.

The disinfectant and deodorant properties of Cl are due to its affinity for Hydrogen. In the presence of moisture,

it combines with Hydrogen and liberates nascent O_2 which destroys organic matter including Bacteria by oxidation.

Delepine strongly recommends that walls, ceiling and floors be brushed with a solution of bleaching powder of a strength of 1 in 100 to ensure more certain contact. Further, the activity of this solution may be increased by adding a little acid to the solution or by producing acid fumes in the air and raising the temperature. The mixture is used in the proportion of 2 ounces of bleaching powder to one pint of water. The difficulty in regard to this very valuable disinfectant is that in a hot climate it is apt to deteriorate and lose its power of destroying microbes. Hankin of Agra states that specimens having a coarse granular powder keep longer than other specimens in which the material forms adherent masses, and summarises a series of experiments thus:—

1. Chloride of lime, *i.e.*, bleaching powder, when fit for use has a strong smell of chlorine. If kept in a hot climate, the amount of available chlorine will be about one-third of the original in about three months, after which time the amount of chlorine may be less and the lime will then be unfit for use.

2. Chloride of lime is readily attacked by various kinds of organic matter. It is therefore unsuitable for dealing with sewage or other large masses of putrefying matter. On the other hand, it may be used with advantage in places where the infective material can only be imbedded in small amounts of organic matter.

3. Owing to its deodorant properties and penetrative powers, it may be used in the interior of infected houses, on the walls, on furniture, or on floors either concrete or cement.

4. Owing to the high bactericidal powers of chlorides of lime, under circumstances in which its action is not masked by the presence of an excess of organic matter, it is likely that it could be useful in cleansing and disinfecting wells, either in place of or in combination with permanganate of potassium; if used for this purpose, the water should be pumped out before the well is passed for use again.

Chloride of lime itself is usually made by passing chlorine gas over slaked lime.

$$2Ca\,(OH)_2 + 2Cl_2 = CaCl_2 + Ca\,(ClO)_2 + 2H_2O.$$

It must be noted that chlorine acts much better when the air is moist, and, as the gas is heavy, it should be generated

in an elevated position. The method so long advocated by Professor Delepine is the routine one in force in the City of Manchester for disinfecting houses, and experiments have proved its great reliability, provided that the chloride of lime is upto proper strength. This is the great difficulty in hot countries, but where a constant supply of comparatively fresh material can be obtained, there is no reason why this method should be less successful here than in colder climates. It, moreover, has the great advantage of being very cheap.

Chlorinated limewash :—

Chlorinated lime 2 oz.

Quicklime 1 gallon.

Water 1 gallon.

HYDROCYANIC ACID GAS.

This gas is particularly useful for destruction of rats and other vermins in ships as it is found to destroy 95% of rats in holds whether loaded or empty. It is quick and certain in its action and does not cause damage to metal-work, paint, fittings or cargo. It is said to be also relatively less expensive in practice.

On the other hand it is a deadly gas and for the safety of the operators, certain precautionary regulations should be enforced. The gas is preferably combined with a warning lacrimatory gas such as Cyanogen Chloride. One of the following preparations may be used :—

HCN and CNCl.—The mixture is composed of NaCN 4 ounces, $NaClO_3$ 1.5 ounces, HCl and water, each 17 ounces, per 1,000 cubic feet of air space. The time of exposure is 2 hours.

Zyklon B.—This is employed at the New York Quarantine station and consists of Diatomite, a porous siliceous earth, holding its own weight of liquid HCN with a tear gas. It is put up in hermetically sealed containers of strong tin which are labelled to show the net weight of HCN.

Zyklon B is poured out on sheets of paper making a layer ½ an inch thick and about 2 ounces of the powder suffice for 1,000 c. ft. For unloaded holds, the exposure should be for 2 hours but for loaded ones the period should be doubled. All posts and ventilators should be closed during exposure.

After the expiry of the period, the ship is opened up. An hour after, a caged white rat is introduced into the hold and its behaviour noted. If the rat is uninjured, operators wearing gas-masks enter to remove the residues. The ship is declared clear, when operators with masks off can enter all parts of the ship without any discomfort from tear gas.

Before commencing fumigation, the Officer-in-Charge must see that all crew from the ship have been removed to a place of safety except two men and the Watch-Officer. Though fumigation with HCN gas is considered as a hazardous occupation, yet with proper precautions outlined above the danger can be reduced practically to nothing. Stoc and Monier-Williams maintain that the fatal accidents which have occurred in England and other countries have been mainly due to lack of precautions or to carelessness of operators.

(For fumigation of railway carriages with HCN gas see p. 963.)

COMPARISON OF THE VARIOUS GASEOUS DISINFECTANTS.

Sulphur dioxide is a heavy gas with a density double that of the atmosphere and, therefore, diffuses badly. Combined with moisture, it has marked disinfectant powers, a 5.0% solution killing even the spores of B. anthracis. It is useful for destroying vermin, being superior in this respect to formaldehyde. The gas is irrespirable and while unsealing the room where it is produced, the operator should place a wet towel moistened with washing soda over the face to enable him to enter. Its disadvantage is that it tarnishes bronze, gilt and copper surfaces, and hence where possible, these should be previously removed from the room after wiping them with 1.0% carbolic acid.

Formaldehyde gas is non-poisonous but very irritating to the eyes and throat. It is most efficacious at temperatures above 70° F and at a humidity of 70.0%. While unsealing the room, goggles especially made to protect the eyes may be worn by the operators. On account of its high diffusibility, it is specially useful where passages, staircases or corridors with communicating rooms require disinfection. It does not tarnish metals nor injure textiles and though actively germicidal it is of limited value against insects which elude it in corners and recesses. Formalin vapour is specially indicated for disinfection of books and as spray for leather goods, furs and feathers.

Chlorine gas is of great service in the purification of water and is of limited use as an ordinary disinfectant since it is toxic to man, less convenient in use and more expensive. It is heavier and more irritant than sulphur dioxide and possesses greater bleaching properties. In unsealing the room after disinfection the operator should place over his mouth a towel soaked in a solution of weak ammonia.

Hydrocyanic acid gas is particularly useful for the destruction of rats and other vermin and insects in the holds of ships. Its properties and the precautions to be taken during its use on account of its deadly nature have already been noted (*vide* page 940).

LIQUID DISINFECTANTS.

Many liquid disinfectants have from time to time been placed on the market. Among the more commonly used ones in India are—

(1) *Mercury perchloride.*—It is readily soluble in water and alcohol. It is very poisonous, corrodes metals and coagulates albumen. As a disinfectant it is very powerful, and in a strength of 1 in 1,000 will kill Anthrax, Typhoid and Diphtheria bacilli in 30 minutes. For spores which are killed in 1 hour a strength of 1 in 500 is required. Its solution is colourless and, as it is poisonous, it should be artificially

coloured, aniline blue being most often used for the purpose. It has no smell and is comparatively harmless to insect life. As it is non-volatile, it is used purely as a local disinfectant. Its antiseptic power is said to be increased by the addition of $\frac{1}{2}$% of hydrochloric acid.

As a disinfectant for urine, it is not so very efficacious, as the salts in urine give up chlorides which unite with the mercury. So also as a disinfectant for sputum and fæces, it is not of so much value, because an insoluble albuminate of mercury is formed and the organisms protected from contact with the fluid. The solution is generally made by taking half an ounce of $HgCl_2$ and adding to it one ounce of HCl strong, three grains of aniline blue and three gallons of water giving a strength of 1 in 1,000.

Mercuric iodide is insoluble in water, but is soluble in an excess of potassium iodide. It is less poisonous than the chloride, and is stated to be twice as strong. For floors, a solution of 1 in 4,000 is used. It corrodes metals like the perchloride.

Mercuric cyanide is as powerful as the chloride and has the advantage of not being precipitated by albumin, gelatin, mucin or organic matters, and is therefore better adapted for mud floors smeared with cowdung. It is somewhat expensive, however. Used with kerosene oil emulsion in a strength of 1 in 50 it makes a good disinfectant for Plague infected houses.

Carbolic acid is prepared from tar distillates, and in the crude state is a dark, oily liquid. Pure phenyle forms colourless crystals turning red in the light. It is soluble in water, to the extent of about 1 in 15. It is expensive, its action is uncertain and even in a strength of 1 in 20 it cannot be relied upon to kill all organisms, nor does it kill the spores of Anthrax. It is poisonous, as it is readily absorbed by the skin and abrasions.

Izal is extracted from an oil obtained in the process of carbonising coke in closed ovens. In water it forms a creamy

emulsion. It is non-poisonous and has no caustic action on the skin. It mixes readily with water in all proportions. Klein found that a solution of 1 in 500 completely disinfected Typhoid stools in 15 minutes. A solution of 1 in 600 renders Typhoid urine aseptic in 5 minutes. A strength of 1 in 800 kills the organisms of Diphtheria, Typhoid, Cholera and Erysipelas in 5 minutes. Not being volatile it is strictly local in its action. It does not injure textile articles to which it is applied and its odour is non-irritating. A one per cent. solution kills Anthrax spores in one hour. It is used in solutions of 1 in 50 for sputum, and one in 400 for rooms and for the wet dusting of furniture. Used in the strength of 1 in 100, it is a good disinfectant for the various infectious diseases.

Lysol is mixable with water in all proportions. It is a brown, transparent, soapy liquid and is said to be practically non-poisonous. Its mode of preparation would appear to make its use, as a general disinfectant on a large scale, impracticable on account of expense. For surgical purposes it is valuable.

Cyllin is a cheap, powerful disinfectant and pulicide. It is easily mixable with water, does not corrode metals, nor does it injure ordinary clothing. It is non-volatile and non-irritating and does not damage wall papers, nor leave any objectionable odour in the room. It can be used in the form of a spray or as a wash. Most frequently it is used in two strengths, *viz.*, for sputum, blood, fæces and for mud floors, walls, cowdung floors, vomited matters, etc., it is used in the proportion of two ounces to two gallons of water, *i.e.*, 1 in 160, and for latrines, drains, clothing, furniture, ceilings, etc., in the strength of one ounce to two gallons of water *i.e.*, 1 in 320.

Equal parts of cyllin and petrol mixed with water form an excellent bactericide and pulicide.

Cresol solution $2\frac{1}{2}$ per cent. is the standard disinfectant now used in the army.

Formalin in a one per cent. solution is frequently used as a spray. It is cheap, rapid and reliable, but has an irritating odour and affects the eyes. It has no action on most metals, except iron, and it does not affect colours.

Lime is a good and cheap disinfectant but it must be fresh. When mixed with water, it forms slaked lime, $Ca(OH)2$. A three per cent. solution of slaked lime kills B. Typhosus in 1 hour. Slaked lime is used as a white-wash after being mixed with water. Milk of lime is slaked lime with 4-8 times its volume of water. It is good as a wash for privies.

Chloride of Lime.—Bleaching powder is obtained by passing chlorine gas over moist slaked lime. It consists of a mixture of Chloride and Hypochlorite of Calcium. The latter is strongly alkaline and is acted upon by the carbon dioxide of the air giving carbonate of lime and hypochlorous acid and this latter in contact with organic matter splits up into hydrochloric acid and oxygen, and it is on this that the action depends. Delepine advocates a process which has for years past been pursued in Manchester for disinfecting rooms occupied by tubercular patients. The walls, ceiling and woodwork are carefully rubbed down with dough to collect the superficial dust and then a solution of chlorinated lime (1-100) is painted on the surface two or three times. The room is then closed and water containing a little hydrochloric acid is evaporated over a small stove. Three hours suffice for the process. The solution recommended is six ounces of powder to three pints of water. Chloride of lime possesses an irritating odour. It corrodes metals. It should contain at least 33% of available chlorine. The workmen must leave the room while the actual process is going on.

Chloramine T.—Dakin has shown that the antiseptic action of hypochlorites depends not upon their oxidising properties as has been formerly supposed, but on the formation of Chloramines from Proteins. One of these is Chloramine T. It is useful as a general antiseptic and in-

strengths of 2·0% is used as a Nasal spray for the treatment of "carriers" of Meningococcus, the germ of Epidemic Cerebro-spinal fever. The exposure should last for 15-20 minutes and should be repeated every day for 3 successive days. A solution of zinc sulphate is as efficient and is better tolerated.

Permanganate of Potassium is most frequently used as a deodorant. It is expensive, it stains clothing and is easily rendered inert in the presence of organic matter. In India it is chiefly used in disinfection of wells.

TREATMENT OF WELL-WATER WITH POTASSIUM PERMANGANATE.

During Cholera Epidemics and on occasions when there is a suspicion that the well-water is contaminated, measures must be taken to purify such waters and the method which is usually followed is to treat the well-water with Potassium Permanganate. The method is cheap and simple and requires no technical skill, so that its operation may be left to unqualified assistants once the process is demonstrated to them. Its only disadvantage is that if the colour persists in the water for some hours, people avoid using the water and try to secure their supply from other sources, possibly contaminated. For this purpose the well should be treated in the evening after the inhabitants have stored their supply for the night, so that any colour persisting in the water after treatment, will be discharged during the night hours and the water will be clear the next morning. As regards the amount of Permanganate to be used for a well, no hard and fast rules can be laid down, as apart from other things, it depends upon the amount of organic matter in the well-water which will be oxidised by the Permanganate, the Permanganate losing its colour in the process. Enough may be said to have been added, when the water turns pink in colour and this colour persists for half an hour after treatment. The process usually carried out is as follows :—

Into a bucket to which a rope is tied, are introduced one to two ounces of Potassium Permanganate Crystals and the bucket is lowered into the well till it is filled up with water. Then it is raised up and the contents stirred with a stick. The bucket is lowered into the well and dipped well under the surface of water. The bucket is raised a second time and the solution again stirred and the bucket lowered into the well again. This process is repeated till the whole Permanganate is dissolved. Finally a sample of water is drawn up and its colour noted. If it is definitely pink, then the operator has to wait for half an hour to see that the colour persists for that period. If it is discharged earlier or if it is not definitely pink immediately after treatment it means that enough Permanganate has not been added. The same process is to be repeated with more Permanganate until the colour persists for the required period. In practice

an excess, is usually added, so that the colour is discharged after some hours during the night.

Ferrous Sulphate acts by its reducing action. Unless in strong solution it acts but feebly. It is a good deodorant, and is used sometimes for disinfecting excreta.

DISINFECTANTS USED IN A SOLID FORM.

These are more useful as deodorants in the form of powders.

Carbolic Powders.—The "vehicle" for such powders is usually lime which is used in excess. The resulting product is a carbolate of lime, there being no free carbolic acid and the powder is practically inert. The best class of carbolic powders are warranted to contain 15% carbolic acid, the base being some silicious matter or wood-fibre or peat.

Slaked Lime may be used as a deodorant as it absorbs sulphuretted Hydrogen and most of the organic vapours.

Equal parts of "sanitas powder" and lime also serve as a good deodorant.

PULICIDES.

As will readily be imagined, rats, bugs, lice and fleas may often exist in places which do not permit of the application of disinfectants or pulicides directly. One would therefore naturally fall back on gaseous disinfectants as a means of combating these vermin. In ships and well-constructed houses such agents may be very successful but, as has already been explained, in the majority of Indian houses such methods are inapplicable. This fact has been well exemplified by Captain Gloster, I.M.S.

One must therefore employ an agent other than gaseous. Saigol, after a series of experiments, dismissed as useless perchloride of mercury, potassium permanganate, formalin, tar, lime, washing soda, sulphuric acid and many other substances. On the other hand, he considered as valuable

phenyle, cyllin and izal, and of these phenyle to be the best. Sommerville states that rat fleas are killed by cyllin 1 in 400, phenyle 1 in 250 and Jeye's fluid 1 in 250, but adds that he would not rely on the application of any disinfectant for this work for a shorter period than 5 minutes.

In Bombay City *pesterine* is the official pulicide. It is applied to the floor and walls by the aid of a brush. It is the crude petroleum (liquid fuel) and in appearance resembles thin coal tar. It is incapable of direct mixture with water, but by the use of soap solution it can be converted into a fluid perfectly mixable with water in all proportions, in which form it is very efficient against fleas, etc. Pesterine and cyllin in equal proportions when mixed and added to 100 times the volume of water give a valuable emulsion of pulicidal value. It can either be sprayed or applied directly to floors or walls. In its crude state pesterine unfortunately fouls surfaces to which it is applied and, consequently, it is open to objection for use in better class houses. In its favour, however, is the fact that it is cheap, easy to apply and very efficient as a pulicide and further, what is a feature of very great importance, it is not likely to be diverted to other uses.

The staff who do the disinfection should wear long coats and protect their feet with shoes or *chuppals* (sandals), and begin operations by sprinkling a little pesterine on the floor. They should then remove all the furniture, etc., and should any fleas be dislodged by this process they will fall into the pesterine already on the floor.

After the room has been emptied, they should spread the pesterine with a long brush over the walls, carefully going over all the nooks and cracks and ledges; this can be quickly done if the brush is held horizontal. A little more pesterine should now be sprinkled over the floor and by means of a broom spread all over in an even manner. Finally, a small quantity should be poured into any rat hole found in the floor. Pesterine may also be used to kill the larvæ of flies and mosquitoes and other insects.

Petrol and heavy *benzine* obtained from crude petroleum prove fatal to fleas on mere contact, and the fumes also kill them in about one minute. Emulsified with cyllin or phenyle, no separation of oily particles takes place on the addition of water, and there is no objectionable odour. Though both cyllin and phenyle emulsify petrol, the former is preferable owing to its greater germicidal power. The emulsion must be made fresh immediately before use ; it is made thus : *thoroughly mix* cyllin or phenyle with an equal quantity of petrol or benzine and then gradually add water, little by little, shaking vigorously until the two appear thoroughly and uniformly mixed. Slight liberation of gas may occur at this stage. This emulsion diluted to 1 in 800, *i.e., in* 1,600 of either, will kill fleas quite successfully.

A mixture of petrol, benzine and crude petroleum, (or 1 : 2 : 3 mixture) also acts as an efficient pulicidal agent. It is made by taking the chemicals in the above proportions and then gradually adding water to the desired extent. Actual contact with the fluid appears to be necessary to kill fleas and the females appear to be the more resistant.

Kerosene Oil emulsion used in a dilution of 1 in 10 also destroys fleas. To prepare this emulsion, take 4 cakes of Sunlight Soap and slice them. Put the soap in an open mouth vessel of 5-6 gallons capacity, add half a gallon of water and boil till the soap dissolves. Now commence adding the oil to the soap solution, beating up the latter thoroughly after every addition of oil and making fresh additions only after noting that all traces of free oil are absorbed into the frothy mass. If properly done, half a gallon of soap solution should emulsify a whole tin of kerosene oil (4 gallons). The time taken to prepare such an emulsion is generally about half an hour.

Captain Gloster, I.M.S., recommends an emulsion of kerosene oil made thus :—Take Sunlight Soap 3 parts and boil in water 15 parts. To this add kerosene oil 100 parts

shaking and stirring all the while. The oil should be warmed carefully before being added. Fleas in a test tube were killed in 2 minutes by a 1 in 1,000 dilution of this emulsion. For earthen floors the emulsion should be used in a strength of 1 in 20 of water. This emulsion has no bactericidal powers. Another one recommended by the same observer is :—

Hydrocarbon emulsion.—Hydrocarbon is a bye-product in the manufacture of gas from kerosene oil. The emulsion is made in the same manner as the former, except that the hydrocarbon does not require any preliminary heating. The emulsion mixes well with water and has a bactericidal action twice as great as that of carbolic acid.

Kerosene oil and cyanide of mercury, in the proportion of 2 of the latter to 100 parts of the former, form an excellent preparation for Indian houses. It is, however, somewhat expensive.

Sunshine as a pulicide.—In a Plague-infected country, such as India, of vast dimensions and possessing comparatively few large cities and towns, circumstances must repeatedly arise when it is desirable to take precautions in regard to the conveyance of infected fleas in the personal clothing and bedding of travellers.

Large numbers of people are continually passing from the towns to the villages, and it is obviously impracticable to suggest steam disinfection of clothing, etc., on arrival, and in many cases even treatment with one or other of the various pulicides mentioned above is out of question.

To meet this obvious difficulty, experiments were conducted at the Haffkine Institute, Bombay, by Captain Cunningham, I.M.S., to test the efficacy of sunshine as a pulicide, and most valuable results were obtained : valuable in that it is now known that precautionary measures can be carried out in practically every village in India, however remote from towns, at no expenditure of money and with but little labour. Certain essential precautions of a very simple

nature have to be observed, however, and these have been fully detailed by Captain Cunningham and may be summarised as under :—

(1) Choose a smooth, sandy place where no grass or bushes grow and which is fully exposed to the sun. It must not be near trees or houses and the ground should have no cracks in it and be free from stones.

(2) If the place is not sandy by nature, it must be covered with a layer of sand three inches deep and made quite smooth on the top.

The sand must be very hot before the clothes are put on it. It is necessary, therefore, to wait till about 10 a.m. before spreading the clothes, and no clothes should be spread after 4 p.m., as the sand will not be sufficiently hot at that hour.

The clothes should be spread evenly on the sand in a single layer and allowed to remain in the sun for the period of one hour.

(3) Thick and padded clothes, such as *resais* and quilted coats, must be turned over once or twice in order to expose both surfaces to the sun.

(4) Clothes must not be placed within three feet of the edge of the sand, as otherwise some fleas may escape and ultimately reach the village.

(5) The sandy surface must be quite smooth and precautions should be taken to prevent cattle straying across the prepared surface prior to the commencement of operations.

It will be seen that this simple precautionary measure is within the reach of any one in any place and practically at any season, and it cannot be too widely known and acted upon by all village authorities in respect of travellers from known Plague-infected centres.

CONCURRENT AND TERMINAL DISINFECTION.

Concurrent disinfection is that which is carried out during the course of a patient's illness. This includes disinfection of the hands of the sick-nurse, the clinical thermometer, nasal discharges, sputa and fæces of the patient with cleaning of all accessible surfaces and their free exposure to light and air. Terminal disinfection is that done on the termination ina house of a case of infectious disease by recovery, death or removal to a hospital. Terminal disinfection has

lately been considered to be superfluous. Generally the infection passes from the sick to the healthy directly and pathogenic organisms disseminated in the air or deposited on the surfaces in the sick-room cannot be held responsible for the occurrence of fresh cases of the disease. Once the source of infection *viz.*:—the patient, has been removed, there is no more "spray infection" and if concurrent disinfection has been practised thoroughly, there remains nothing for terminal disinfection. A few organisms deposited on the walls or ceiling and other surfaces in the room cannot live long, being obligate parasites, so that a final domestic cleaning up is all that is required for their disposal.

It is not surprising, in view of these facts, that terminal disinfection has been abandoned in cases of Diphtheria and Scarlet Fever in some cities in America and the results of this procedure have not been found to be bad in any way.

Though terminal disinfection thus seems to be valueless, when concurrent disinfection is practised efficiently, still it must be remembered that this procedure has not been generally followed. Taking into consideration the education and intelligence of an average individual and his want of capacity to understand properly the need for disinfection in a case of infectious disease, one hesitates to recommend the abandonment of terminal disinfection altogether in this country. To be efficient, terminal disinfection must be practised with proper attention to all details and under the supervision of a trained staff.

DISINFECTION OF EXCRETA AND DISCHARGES.

In certain diseases this is a most essential duty, *e.g.*, the urine and bowel discharges in Typhoid, the sputum in Phthisis and Lobar and Plague Pneumonia, the discharges from the throat and ears in Scarlet Fever and Diphtheria and the discharges from the nose, the vomited matter and fæces in a case of Cholera, etc., etc. For this purpose there is a large choice of disinfectants. One may use izal 0·5% or acid

carbolic 10 per cent., chinosol 1 in 500, cyllin 1 in 160, cresol or zondo fluid. The whole should be well mixed and allowed to stand for 1 to 3 hours and then discharged into the sewer, or failing a sewer, buried deep well away from any source of water-supply or risk of contamination thereof. For Cholera dejecta equal parts of quick lime and water may be mixed and this slake so formed may be diluted with three times as much water as was formerly used. Now equal parts of this mixture and the Cholera dejecta should be well mixed and allowed to stand for one hour, after which the vibrios will be dead. Similarly, good chlorinated lime in the proportion of two tablespoonsful to a pint of Cholera dejecta is effective in 20 minutes. For Typhoid bacilluria one per cent. formalin solution is effective. Great care must be taken in destroying all discharges from the mouth, nose, throat or lungs and ears of persons suffering from Scarlet Fever, Diphtheria, Whooping Cough, Measles, Small-pox and Cerebro-spinal Meningitis. These can be destroyed by fire or by chemical disinfectants. In some places the fæces, etc., are sterilised by steam, or boiling, and after cooling are discharged into the drains.

The disinfection of sputum in the case of phthisical patients and Pneumonia patients is of the utmost importance. In isolated cases the use of izal solution is quite satisfactory but in the case of a large institution set apart for consumptives, where in all probability there is a steam laundry, etc., working in the institution, a more satisfactory method of disposal would be by steam, which is already available. Goddard, Massey and Warner have introduced for the purpose an apparatus for which they claim the following:—

The apparatus consists of a steam chamber, with galvanised baskets for receiving the sputum mugs, "pocket" bottles or jars, which are used by the patients under treatment.

These vessels when containing sputum are placed into the baskets for disinfection, the receiving door of the apparatus is then closed and the whole contents are subjected to

temperature of 126 degrees Centigrade; the process of disinfection is allowed to remain in operation for a few minutes, after which the cylinder carrying the galvanised baskets is revolved, by which action the disinfected sputum empties itself into the bottom of the disinfector, and is then discharged under pressure into the sewer or drain. Hot water is then admitted into the chamber for cleansing the inside of the chamber, baskets, mugs, bottles, etc., the cylinder again revolved, and when the cleansing process has proceeded for a short time, the hot water is run off into the sewer, and the whole of the contents are ready for use again.

With this apparatus three very important results are obtained:—

1st—The phthisical sputa are satisfactorily disinfected all the germs being destroyed after the process; therefore the liquid is free from infection, and may be run direct into the sewer or drain without fear of infection.

2nd—No germs of phthisis adhere to the vessels being used again, as the mugs and vessels themselves are subjected to thorough disinfection. The vessels used by the patients are ready for use again, after being taken out of the machine, perfectly cleaned, without the use of any separate cleansing and thus the nauseous and dangerous process adopted in the absence of the apparatus is avoided.

3rd—The process of disinfection is easily performed, the whole operation only taking a few minutes; therefore the expectorations contained in the vessels used by the patients between each meal hour may be disinfected three times a day, at very little trouble to the attendant.

The medium by which the germ is surrounded is an important factor demanding most careful consideration.

On the one hand it acts mechanically by protecting the germ from the activities of the germicide. In order to kill a particular organism with a particular disinfectant the one must come in contact with the other. Typhoid bacilli in laboratory experiments may be quickly killed by a dilute solution of carbolic acid but such a solution may be without effect to kill the same bacilli in typhoid stool simply because the bacteria are imbedded in the fæces and direct contact is not established. We have to take steps to intimately mix the excreta and the disinfectant and to allow the latter to have time to penetrate and reach the bacilli. The same thing applies to the disinfection of tuberculous sputum. The albuminous matrix of the sputum affords a very considerable protection to the already naturally resistant tubercle bacilli.

The extremely high germicidal properties of free chlorine would be utilised and utilisable to a far greater extent if it were not for this factor. The free chlorine combines with organic matter first, and a very large part of its potency is lost in this way.

Similar remarks apply to the action of corrosive sublimate (mercuric chloride) which combines readily with organic matter, the substance so formed being possessed of little or no germicidal action. This point is of very practical importance in connection with disinfection of poor class houses and chawls in Bombay, where the floors are covered over with cow-dung. In such houses disinfection should be done either by carbolic acid, izal, zondo or such other coal-tar derivatives.

DISINFECTION OF THE HOUSE.

The choice of method depends largely on the character of the house to be disinfected and on the nature of the disease for which disinfection is required. In the absence of any contra-indication, a gaseous disinfectant can be used, either formalin, chlorine, or sulphur. Should, however, obvious

impediments exist to the use of such, then sprays or washes may be employed, *e.g.*, perchloride of mercury in a strength of 1 in 1,000 ; or formalin, strength 4 ounces to 1 gallon ; or chloride of lime as a wash using a solution of the strength of 2 ounces to the pint of water. There are many forms of sprays on the market, *e.g.*, Defries', Mackenzie's, or Robertson's. When the disease is spread by insects, *e.g.*, fleas or bugs, and gaseous disinfectants cannot be used, then one or other of the pulicidal emulsions mentioned above may be employed.

Whatever agent is chosen and in whatever form it is applied, it is most important that no part of the house be overlooked. The staircase, privies and washing places must all be disinfected. If cloth ceilings exist, they should be removed and a careful search made for rats ; so also, every accumulation of lumber must be removed and any rats found destroyed.

The furniture must be disinfected, horse-hair or leather articles may be washed or sprayed with formalin solution or perchloride of mercury. All articles of wood should be washed with soap and water, and in the case of wooden bedsteads, tables and chairs, pulicides can be freely used.

All cooking and eating utensils of whatever nature must be carefully washed with soap and water and subsequently with izal or other suitable disinfectant in those cases where infection is likely to be conveyed by means of articles of food or drink.

DISINFECTION OF THE CLOTHING.

All clothing and bedding which has been exposed even remotely to infection must be collected and a duplicate list thereof made ; one copy is to be given to the householder and the other retained by the Inspector. Should any clothing or bedding be in a damaged condition, careful note should be recorded of the fact. Concealment of infected clothing must be guarded against. When collected, the articles should

be removed to the disinfection station in a covered vehicle before the disinfection of the house is commenced. At the station they are disinfected by steam, when such an agent is permissible. In some towns blankets are not subjected to steam, on account of the tendency of that agent to alter their texture and colour, but instead they are placed in a disinfectant fluid. Articles of but little value may be destroyed after obtaining the owner's consent in writing. After disinfection, the clothing, etc., is brought back in a vehicle which must always be reserved for disinfected clothing only. The Inspector should obtain a receipt from the owner for the return of the clothing and also a statement as to the condition in which it has been returned : any neglect of this precaution may result in claims for damages, imaginary or real, being sent in at a later date. This, therefore, should never be omitted.

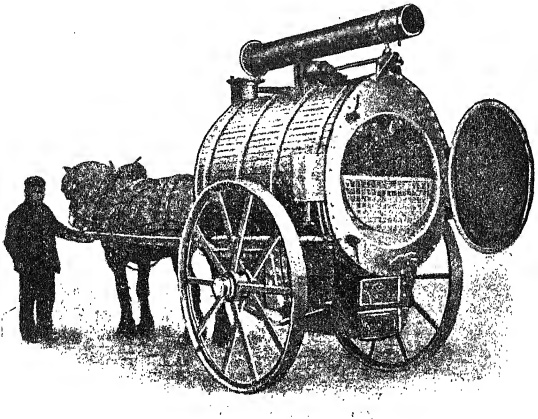
Personal underclothing may be similarly treated. Other articles of clothing may be exposed to formalin vapour or spray. Washing suits should be placed in one or other of the above disinfecting solutions, subsequently boiled and then exposed to the sunlight. Blankets should not be boiled.

DISINFECTION OF OTHER MISCELLANEOUS ARTICLES.

Boots and other leather goods, furs, rubber goods, silks, brushes, combs, and feathers may be removed to the station and there treated with formalin vapour or a spray of formalin 2 per cent. Books, if of little value, may, by consent of the owner, be burned; but if it is desired to retain them, then, they can be treated with formalin vapour. This is usually carried out in a cupboard compartment, in which books are disposed on shelves of perforated zinc gauze in such a manner that the pages are opened out, or the books may be suspended on wires from the top of the chamber. Fumigation should be carried out for two or three hours. Kister and Trautman recommend a method which is carried out as follows : the books are placed in a

steam disinfecting apparatus fitted with a vacuum producing arrangement, formalin is placed in a vaporiser at a point in the oven most distant from the vacuum apparatus, and as the pressure inside the oven is reduced, formic aldehyde and steam are liberated at about 80° C: this is continuously sucked through the apparatus for thirty minutes, the books being so arranged as to be covered by the vapours.

In districts where no public disinfecting stations exist, disinfection may be carried out by means of portable small disinfectors (steam), which visit the houses where the process is to be carried out. If no such disinfector is available, other measures must be adopted. Mattresses, if badly soiled, should be burned, sheets should be soaked in izal, 1 in 400, or carbolic acid 5 per cent. or cyllin 1 in 320 for 1 to 2 hours, and then boiled and washed in soap and water.



THE PORTABLE DISINFECTOR.

INSTRUCTIONS TO THE DISINFECTING STAFF IN BOMBAY.

Inspectors in charge of disinfecting plant should exercise great vigilance in seeing that the correct temperature is maintained and that sterilised articles are not allowed to re-enter the room reserved for infected articles. For this reason most sterilisers have two doors opening into separate rooms and these rooms must never be considered to be interchangeable and there should be no direct communication between them. Further, separate vans must be kept for infected and disinfected articles. A mistake to be carefully guarded against is the habit of packing too many articles in the apparatus at one time, with the result that some of the articles are so closely wedged that it is practically impossible for the steam to penetrate the interstices, the disinfection thus remaining un-accomplished; the articles should be comparatively loosely packed. If, for one reason or another, the Inspector on visiting a house is not able to wait for the arrival of the disinfecting gang, or the infected clothing van, he should arrange for a preliminary disinfection of the clothing on the spot. For this purpose he should carry perchloride of mercury tablets and personally see that such articles as sheets, handkerchieves, night-clothes, etc., which have been soiled, are immersed in a solution of this disinfectant, while awaiting the arrival of the van. In the presence of a serious epidemic of Cholera, etc., this is a valuable safeguard, as it lessens the chances of the articles being handled by the inmates and also of flies becoming the means of disseminating the disease, as, if the outbreak is of serious extent, many hours must of necessity elapse before the van arrives. A further point, which should never be omitted, is to see whether a well exists on the premises; if so, and the disease is a water-borne one, precautionary disinfection of the well should be done by the Permanganate process (see p. 945) Disinfection of the water taps also should be carried out as a routine practice, since infected

clothing is frequently placed on one tap while washing is carried out at another.

In regard to the privies , the Inspector should see that not only the seat, floor and walls are disinfected, but also, if the privy be of the common basket type, the receptacle and its contents, if the disease for which disinfection is being carried on, is one in which the excreta are likely to convey infection, *e.g.* Cholera, Typhoid, etc. By this means the risk of conveyance by the agency of flies is lessened. Izal 1 in 200, carbolic acid 1 in 10, or cyllin 1 in 160 or cresol solution $2\frac{1}{2}$ per cent. may be used for the purpose. This is an important point which should never be overlooked. Finally, the Inspector in carrying out disinfection of a house should always exercise tact and discretion, remembering that at the best the process is one which involves some degree of discomfort to the occupants. He should see that no wanton damage is done and, as far as possible, study the convenience of the occupants never, however, permitting this to conduce to an imperfect disinfection. Very often a few words, indicative of his object and the scope of his intended operations, will serve to allay any spirit of opposition that may be evinced and should they not do so, the Inspector has always the support of the law to fall back upon. This he should not put in force himself, but report to his superior officer and await further instructions.

DISINFECTION FOR CHOLERA.

1. Inspector must ascertain in every case whether all the personal clothing worn by the patient and all the bedding and any articles of attire, which may have been soiled by vomited matter or fæcal discharges, has been collected and dealt with by the District Registrar or his staff on his preliminary visit. The District Registrar has instructions to immerse all such articles in *perchloride solution* pending the arrival of the disinfecting staff. The Disinfecting Sub-Inspector must remove all infected clothing for steam sterilization.

N.B.—It is of the utmost importance that no infected article be overlooked and it will be considered a very serious neglect of duty if any instance of such is detected.

2. *All water taps* must be carefully washed with freshly prepared permanganate solution and the water allowed to flow freely for a few minutes afterwards.

3. Careful search must be made to see if *any well* exists in the premises if so, it must be treated with permanganate solution.

4. *Every privy seat* should be carefully scrubbed with a brush, using plenty of water with some *izal solution* in it. The walls and floor of the privy must also be well washed with the same solution. If necessary, *pesterine may be applied subsequently.*

5. As far as possible all drinking utensils, plates, knives, &c., and all chatties should be well washed in a *solution of izal* and subsequently washed in clean tap water.

6. *The rooms* should be carefully swept (after removing all furniture) and then *disinfected with perchloride solution or izal.* The furniture should be well rubbed with a cloth soaked in izal solution, and any table or article of furniture that will permit washing should be so treated.

7. The members of the family should be informed that it is essential to observe the greatest strictness in regard to cleanliness of their hands and utensils when taking food. All excreta from patients must be treated with the disinfectant supplied.

8. The privy bed and receptacle and also the trap door, if present, and the walls should be most carefully cleansed under the personal supervision of the Sub-Inspector. After thorough cleansing, the whole trap should be treated with pesterine. The object of so doing is to lessen the risk of conveyance of the disease by the agency of flies; and it is most important that the work be carried out in a conscientious and thorough manner. This procedure must be carried out in the case of Typhoid Fever also. Printed instructions on the prevention of the disease should be given to the relatives.

DISINFECTION FOR TYPHOID OR ENTERIC FEVER.

Typhoid Fever or *Enteric Fever* is conveyed by the ingestion of some article of food or drink, which has become infected with the Typhoid bacillus. Water, milk, vegetables, shell-fish, ice-cream, etc., etc., may all serve as media for the bacillus to retain its infective character. Flies have been proved to convey the germs of Enteric and other diseases to food, and a frequent source of contamination is the eating of food without preliminary washing of the hands after contact with a patient suffering from Typhoid or with infected clothing.

It is most important therefore, that the Inspector should faithfully carry out the following rules :—

1. All infected or soiled personal linen, etc., and bed-clothes should be at once placed in a solution of izal fluid 1 in 200 and allowed

to remain there until the disinfection of the house is completed. On completion, the clothes should be removed to the van and taken to the steam sterilizer.

2. The mattress (if any) should be removed to the steam sterilizer.

3. The walls, floor, door and seat of the privy should be thoroughly washed with izal solution. This must be done most carefully and thoroughly, as the risk of infection being conveyed in this way is considerable.

4. It is specially important that all utensils used by the patient for eating or drinking should be thoroughly washed in izal fluid and then in pure clean water.

5. The walls, floors and ceiling of the room or rooms should be washed with perchloride of mercury solution, or izal, care being taken to prevent dust rising and thereby increasing the risk of the disinfecting gang contracting the disease.

6. All water taps should be carefully washed with freshly prepared permanganate solution and the water allowed to flow freely for a few minutes afterwards.

7. Careful search should be made to see if any well exists on the premises. If so, then it must be thoroughly treated with permanganate of potash solution.

8. If the privy is on the basket system, the Disinfecting Sub-Inspector must make arrangements for the complete disinfection of the iron receptacle with izal and the thorough cleansing of the privy trap and trap door. This should be done under his personal supervision to lessen the risk of conveyance of infection by flies. After thorough cleansing, the whole trap should be treated with pesterine.

N.B.—This procedure must be carried out in the case of disinfection for Cholera also. Printed instructions should be given to the relatives.

Supplementary Order.

As there still appears to be some doubt about the procedure in regard to disinfection of the clothing of Cholera patients, the attention of the District Registrars is once more drawn to the necessity of their carrying a small bottle of perchloride tabloids with them. (An empty Burroughs and Welcome quinine bottle is handy and compact in which to carry them.)

On reaching the patient's house, all infected clothing should be *immersed* in a solution of perchloride, *not* sprinkled with it. This is merely to safeguard against the spread of infection, while waiting for the infected clothing van to come along and remove the clothes for steam disinfection. It is *not* meant to replace the latter. This must occur as usual.

DISINFECTION FOR SMALL-POX.

(See 'Disinfection by Sulphur Dioxide', supra).

1. It is important that every article of personal clothing and bedding be very thoroughly disinfected. No article which has been in contact with the patient should be overlooked.

2. Any articles of furniture which can be washed should be thoroughly washed with soap and water and afterwards well rubbed with a cloth soaked in izal solution and finally rubbed with a dry and clean cloth.

3. All carpets, rugs, etc., should be removed to the steam sterilizer for disinfection.

4. The floor, walls, doors and ceiling should be well scrubbed, using a solution of perchloride of mercury or izal solution.

5. The privy seats, walls and doors should be well washed with water and then scrubbed with a brush, using perchloride of mercury solution or izal to disinfect with.

6. All utensils used by the patients for eating and drinking must be carefully washed in a solution of izal and subsequently in pure water.

7. The bedstead (if any has been used) should be disinfected as far as possible. If made of wood, it should be wiped thoroughly with a cloth soaked in perchloride solution; if of iron, then izal solution should be used.

8. On no account should the keeping of the crusts of old small-pox pustules be permitted. If found, the Inspector should at once destroy them by fire or by strong izal solution. Contacts should be re-vaccinated and printed instructions should be given to relatives.

DISINFECTION FOR PHTHISIS.

As far as our present knowledge goes, the two main channels by which Phthisis is spread are (*i*) milk and (*ii*) the inhalation of infective dust containing Tubercle bacilli from the expectoration of an infected person.

In disinfecting for Phthisis, therefore, it is very important that as little dust be stirred up as possible.

1. All the walls, the ceiling and the floor should be carefully swept with a brush, round the end of which should be wrapped a cloth well soaked in perchloride solution. It is very necessary that this cloth be damp as otherwise much dust will be disturbed and the risk of the disease being contracted by the staff thereby greatly increased.

2. Having removed the bulk of the dust in this manner, the walls, ceiling and the floor should be thoroughly disinfected by the application of perchloride solution or izal.

3. The furniture should be wiped over with a cloth soaked in perchloride or izal solution. Any article that can be washed without harm should be so dealt with.

4. Any handkerchief or rag, etc., soiled by expectoration should, with the consent of the owner, be destroyed by fire; failing the necessary consent, the Inspector should disinfect it by izal solution first and subsequently by steam.

5. All personal clothing, bedding, etc., used by the patient should be removed at once for steam sterilization.

6. As privies are often fouled by expectoration, they should be carefully disinfected with izal solution and subsequently well flushed with water and finally pesterined. The floor, door, walls and seat should all be disinfected.

7. It is most important that no dust (in whatever position it may be in the room) be overlooked as the Tubercle bacillus, the active cause of the disease, will live for a long time in dust and is capable of spreading the disease.

Leaflets on the prevention of Tuberculosis should be given to relatives.

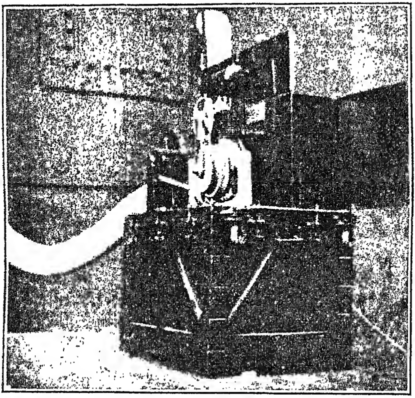
* DISINFECTION OF RAILWAY CARRIAGES.

Disinfection of a railway carriage is done whenever a compartment is occupied by a person suffering from any of the Contagious or Infectious Diseases scheduled under the Railway Act. Similarly disinfestation is sometimes necessary to destroy bugs and other insects and cockroaches and ants in the kitchens of restaurant cars.

Disinfection is carried out by primary fumigation with formaldehyde gas, after the usual precautions as regards closing the doors and windows and pasting paper on the chinks, etc., have been observed. The gas is generated by the formaline permanganate process (see page 936). The duration of exposure to the gas is 3 hours after which the

* We are indebted to the Principal Medical Officer of the G. I. P. Railways for the information regarding the method of disinfection and disinfestation of railway carriages.

doors and windows are opened and the carriage thoroughly ventilated. Subsequent to this, carpets, upholstered seats and back-rests, if removable, are taken from the car, washed with a disinfectant solution and exposed to the sun for several hours. Places which are badly contaminated with infective discharges are saturated with formaline solution 1 in 20. Floor sweepings are burnt and the floors then mopped or scrubbed with a disinfectant solution. Similarly door-knobs and other surfaces handled by the patient or soiled with discharges are wiped with the disinfectant solution. Special attention is paid to water-closets and bath rooms which are also treated with the disinfectant fluid.



GLEN LISTON APPARATUS FOR GENERATING HCN GAS.

Disinfestation is carried out by fumigation of the carriage with HCN gas. The machine used for the purpose was devised by Col. Glen Liston and has been in use for over 20

years. It is kept in the open air and is connected by means of inlet and outlet pipes, with the carriage which is rendered air-tight. The gas is generated by mixing dil. Sulphuric Acid and Pot. Cyanide Solution which are run separately into a generating box in the machine. The gas, as it is evolved, gets diluted with air which is drawn from the carriage by a fan through an inlet pipe and is driven back along the outlet pipes into the carriage. As more gas is generated, more air is withdrawn from the compartment into the machine and this air after taking more gas is passed through the fan along the outlet pipe, back into the carriage. The mixture of air and gas in the carriage is thus continuously circulated through the machine and gas is added to the air until the desired concentration has been obtained. This takes usually 45 minutes. After this, the fan is stopped and the carriage is allowed to stand for four hours before the doors and windows are opened. From the time of opening the doors and windows, a period of about 12 hours is allowed to pass before any one enters the carriage.

The method is absolutely safe and reliable and if all connections are properly made air-tight, there should be no smell of HCN gas round about the carriage.

CHAPTER XI.

Dangerous, Offensive and Other Trades.

A Sanitary Inspector may at any time be called upon to submit a report on a particular trade proposed to be established, or perhaps already established. This necessitates that not only he should know the main processes the articles are subjected to, but also that he should possess a sound judgment and the power of accurate observation.

It may be, and in Bombay frequently it is the case, that a complaint in regard to an alleged offensive trade is based on personal animus or rivalry only, and has no foundation in fact; but however obvious it may appear to the Inspector that such is the case, he should in every instance go in and inspect the works and make sure from personal observation that there is no reasonable ground for complaint, before dismissing the complaint as one due to personal feeling.

On the other hand, the Inspector must not be misled as to the true nature and results of any particular trade carried on in his own district by the absence of any complaints from residents in the vicinity, for, as pointed out by Ballard, several factors may account for the quiescence of such residents. For instance, it may well be that the majority of residents in the neighbourhood of any suspected works are employed in those very works and refrain from complaining from fear of discharge on the information leaking out. The social position of the individual whose works are causing a nuisance may stave off complaint, so also may neighbourly feeling influence those most concerned. Further, it must be remembered that constant exposure to trade effluvia is apt to render them less sensitive to their influence and, again, in a neighbourhood, where many works of a similar nature are carried on, it may be difficult for the person annoyed to definitely locate the source, and consequently he abstains from making a complaint.

As a rule, the most offensive effluvia are those given off in processes in which the materials used consist mainly of animal matter, *e.g.*, the manufacture of artificial manures, gut cleaning and scraping, and the preparation of sausage skins and the melting of fat.

Certain processes dealing with vegetable substances can also be very objectionable, *e.g.*, the boiling of linseed oil, the manufacture of palmitic acid from cotton seed and palm oil.

Ballard, in his report to the Local Government Board, points out that the extent to which trade nuisances spread and their degree of intensity are influenced by many factors. In regard to the first point, this may vary from a few yards to several miles, and is influenced chiefly by (1) the *nature of the effluvia*.—If the effluvium consists of vapours of high density and but little diffusive capacity, it does not so readily travel to a distance, as would be the case if it were of less density and greater diffusive capacity; but at the same time, it must be remembered that the very fact of more ready diffusibility means attenuation of the nuisance if the area affected by the effluvium is extended; (2) *height of discharge of the effluvium*.—If near the ground level, nuisance is more likely to be caused in the immediate neighbourhood than at a distance; (3) *nature of surroundings of the works*.—If this be open country, where there is perhaps nothing to impede the free passage of vapours, they may be a source of nuisance to people one or two miles away, even though the vapours be discharged close to ground level, whereas similar vapours similarly discharged in a town, or in a place where their free passage through the air is obstructed by buildings or other objects, may give offence only to persons residing within the limits of those buildings or of other obstacles; (4) *atmospheric conditions*.—The amount of moisture in the air and the force and direction of the wind and also the temperature of the air modify the distance to which effluvia will travel and their intensity. When the air is saturated

with moisture and there is little or no wind, effluvia will hang about the immediate neighbourhood, even if discharged at some height. In clear weather, when there is little or no excess of moisture in the air, the effluvia will readily pass to a distance and be perceptible in the direction in which the air is moving. In a still atmosphere, the effluvia, if discharged at a low level, hang and diffuse themselves about the works, but if discharged at a high elevation from a chimney, they tend to rise to a still higher level with the heated column of air, and may there meet with a current of air which will drive them in some particular direction, and, before they finally reach ground level again, they have become greatly attenuated by diffusion and are therefore less likely to cause nuisance.

A steady, high wind, especially if moist, may carry effluvia in a more or less intense form to a considerable distance.

Atmospheric temperature also exercises an influence. High atmospheric temperature favours rapid decomposition of organic matter and consequently effluvia are given off readily, the presence of which is felt more in such weather. In connection with trade-effluvium-nuisances one of the most difficult questions to determine is to what extent, if any, such effluvia are injurious to health. If in connection with any trade the statement is made that it is a nuisance or injurious to health, it may mean, to quote Ballard again, "that exposure to the offensive effluvia causes bodily discomfort or other functional disturbance continuing or recurring as the exposure continues or recurs, and tending by continuance or repetition to constitute, though perhaps not a clearly defined form of disease, an appreciable impairment of general health and strength. Such a definition is applicable to those cases in which functional disturbances unquestionably arise as the result of the impression made by the offensive effluvia on the senses. The results may include loss of appetite, nausea, vomiting, diarrhœa,

headache, giddiness, faintness and a general sense of malaise and depression. Or, on the other hand, it may mean that persons exposed to the effluvia are more deeply and permanently damaged in health, that their lives are shortened or pursued in chronic ailment, and that they are more liable than other people to the invasion of definite forms of disease, or that diseases with them are liable to run a less favourable course than with other people."

This definition includes deeper and more serious disturbance to health and includes workers in lead, phosphorus, arsenic, and those working in atmospheres largely charged with the vapours of sulphuretted hydrogen, chlorine and carbonic acid, or with the exhalations from decomposing organic matters.

Trade effluvia form an element of the atmospheric insalubrity of towns. Definite chemical substances, whose vapour is irritant or poisonous, are unquestionably dangerous and it is fallacious to impute disinfecting qualities to them. Effluvia of septic origin are unwholesome.

The interpretation of the word 'nuisance' has similarly given rise to much controversy.

CLASSIFICATION, CAUSES AND PREVENTION OF NUISANCE.

(*a*) CLASSIFICATION.—Nuisances in a *legal sense* are of two kinds : (1) *nuisances at common law,* (2) *statutory nuisances.* Sanitary authorities are concerned with the latter variety only.

Winter Blythe defines a 'statutory nuisance' under the Public Health Acts as something which either actually injures or is likely to injure health, and admits of a remedy either by the individual whose act or omission caused the nuisance or by the local authority. As now read, the idea of a nuisance embraces future as well as present consequences.

At common law, a nuisance may be either *public* or *private,* or a mixture of both. Mr. Justice Stephens defines a

'public nuisance' as an act not warranted by law, or an omission to discharge a legal duty, which act or omission obstructs or causes inconvenience or damage to the public in the exercise of rights common to all His Majesty's subjects. A 'private nuisance' he defines as anything done to interfere with the proprietary rights of another in land not amounting to a trespass.

The London Public Health Act extends the definition of nuisance, making it include not only that which is injurious to health but also that which is dangerous to health.

As defined in Bombay Act III of 1888, a nuisance includes "any act, omission, place or thing which causes, or is likely to cause, injury, danger, annoyance or offence to the sense of sight, smelling or hearing, or which is, or may be, dangerous to life or injurious to health or property."

Ballard in his report adopted a classification of the various trades which may give rise to nuisance or be dangerous to health, and that classification is the one most usually followed on account of its simplicity. It is as follows :—

(1) The keeping of animals. (2) The slaughtering of animals. (3) Branches of industry in which the matters dealt with are of (*a*) animal origin, (*b*) vegetable, (*c*) mineral, or (*d*) of mixed animal, vegetable and mineral origin.

(*b*) CAUSES.—In dealing with offensive trades, it may be considered that should a nuisance arise, it is due to one or other of the following causes or to a combination thereof :—

1. The use of buildings unsuited structurally for the purpose.

2. An untidy or filthy condition of the premises and utensils.

3. An improper method of receiving or disposing of offensive materials used in the trade.

4. An improper mode of storing offensive materials or products on the premises.

5. Removal from the premises of filthy material in improper receptacles.

6. The escape of offensive gases or vapours generated during some part or parts of the processes carried on, and their passage into the atmosphere surrounding the works.

(*c*) PREVENTION.—There are certain general principles of prevention of nuisances which are applicable more or less to all these trades, and, to avoid needless repetition later on, they may be stated at this stage.

1. Such structural and working arrangements should be made as will tend not only to prevent defilement but also assist cleansing, and those parts of the premises liable to become dirty or encrusted with filth or decomposable matter and all utensils used in the trade must be regularly cleaned.

2. Offensive matters necessary for use in the business must be brought into the premises either in covered impervious vessels, or covered up in such a manner that they shall not be a source of effluvium-nuisance during transit. Offensive products should be similarly removed from the premises.

3. Offensive materials and products of the business should either be stored in impervious vessels, or in a closed chamber ventilated if necessary.

4. All filth should be collected in impervious covered vessels and removed from the premises daily.

5. Solid offensive matters should be separated from fluid as far as practicable, and each disposed of in its own appropriate manner, the solids being removed in covered vessels and the liquids being run into drains. Deodorants may sometimes be used with advantage.

6. Where the evolution of offensive gases or vapours is not avoidable, they must be intercepted in their passage to the external air and dealt with in such manner as to destroy their offensive character.

One method of interception consists in arrangements for drawing off in a continuous manner the air of the entire chamber or workshop in which the effluvia are evolved. When so drawn off or collected they may, according to their nature, be dealt with in one of the following methods :—

1. They may be discharged into the atmosphere at such an elevation as will ensure their being so dilute before reaching ground level again as to be comparatively inoffensive.

2. If the evolved matters be condensable by cold, they may be passed through an appropriate condensing apparatus.

3. If soluble in water or other liquid, they may be so treated.

4. Certain solid substances with which the effluvia may have chemical affinity may be used.

5. If the evolved matters are combustible, they may be burned.

NUISANCES ARISING FROM THE KEEPING OF ANIMALS.

The law clearly recognises the fact that animals may not be so kept as to be a nuisance or injurious to health. In the Public Health Act, England, 1875, Section 91, certain statutory nuisances are defined which may be dealt with summarily. Among these occurs the following :—" Any animals so kept as to be a nuisance or injurious to health." In the Bombay Act III of 1888, section 384, sub-section (1), clause (*b*), we find 'no person shall keep any animals on his premises so as to be a nuisance or dangerous to any person.''

Nuisance naturally occurs chiefly where the population is aggregated, and it is more likely to be serious in character where such is dense than where it is sparse, but it is not solely in such circumstances that nuisance may arise ; a solitary animal badly kept in or near an isolated house may have an injurious influence on the inhabitants of that house.

The nuisance is at its maximum intensity, perhaps, when in a close passage or blind alley in a densely populated area, several stables badly constructed and cleansed are permitted to be erected. In such places one may notice a persistent ammoniacal odour which may be perceptible at some distance. In Bombay it was a common practice to construct horse stables on the ground floor of dwelling houses. In many instances the syce, his family and relatives lived in the stable, constructing a dwelling place either by partitioning off a part of the stable or by constructing a loft on bamboo supports. The great majority of these stables were badly lighted and ventilated. In regard to cows and buffaloes, a usual practice was to have the animal in one of the dwelling rooms or in the *chowk* or ventilating shaft of the house. Another favourite place was under the stairs.

Now, as in all houses the staircase, and central *chowk* where such exists, form the main channel for the circulation of air inside the house, it is obvious that the rooms abutting on these ventilating shafts must derive their air from vitiated sources, more especially seeing that in practically every instance the cubic and floor area available for each animal is grossly insufficient, the lighting bad and drainage totally absent. Add to this the fact that gross overcrowding of human beings generally exists in the same house and the magnitude of the evil is at once apparent.

In regard to horse stables under dwelling rooms, as usually constructed, whatever effluvia arise from the stable they find their way into the residential parts above. Their passage upwards is facilitated in some instances by the staircase leading to the upper rooms being in more or less direct communication with the stable, but even where this is not the case and there is an entrance separate from the stable, the pervading stable odour may still penetrate to the rooms above, either through cracks in the ceiling or imperfections in the brick work or wooden work of the structure itself.

The effluvium-nuisances resulting from the keeping of animals proceed mainly from fermenting solid and liquid filth in the stable due to neglect of proper cleansing, from the too protracted use of dirty and sodden litter, from the soaking of urine and excremental matter into the floor as the result of its bad construction or of deficient or inefficient arrangements for drainage. Further, the disturbance of neglected heaps of manure and their cartage through the streets, and the exhalations from the animal's lungs and skin and, in some instances, from diseased surfaces are also sources of possible nuisance. Experiments have been made repeatedly and the results show the necessity for good ventilation in stables, if the air is not to become grossly vitiated and their presence a source of nuisance to the neighbourhood. Obviously, when otherwise, such stables must exercise a most harmful effect on the neighbours and much more so on those people living in the stable itself, not only on account of the direct effects of contaminated air on themselves, but also the indirect ones on their food which is stored and cooked there.

Apart from such stables being a source of nuisance and danger by reason of offensive effluvia, we must remember that one of the principal breeding places of flies is horse litter, and in a city in which the open basket system of conservancy obtains in some places the risk of Cholera and Typhoid being spread by their agency is by no means negligible. Further, old stables are often riddled beneath by rat runs and, where these communicate with adjoining houses, they not only serve as a channel for the introduction of concentrated effluvium, but also of rats and thereby add to the chance of the inmates contracting Plague. To obviate the danger, the following section has been added to the Municipal Act :—

384A. Where a building or any portion thereof is used or intended to be used for human habitation and any portion of such building is used for any of the following purposes, namely,

(a) for keeping any horse, cow, buffalo, bullock, goat or donkey, or

(b) as a godown or place for the storage, in connection with wholesale trade, of grain, seed or groceries, the Commissioner may, if it shall appear to him necessary for sanitary reasons to do so, by written notice require the owner or occupier of such building to discontinue the use of such building for any such purpose: provided that the Commissioner may permit such use subject to such conditions as he may think fit to prescribe.

In improperly drained stables, the possibility of breeding mosquitoes must not be overlooked.

For summary of By-laws relating to Horse, Cattle and Milch Cattle Stables, *Vide* Chapter I, pages 51 to 54.

THE KEEPING OF PIGS.

The nuisance which may arise from this cause is so great as to call for special legislation, and one finds that the Public Health Act, England, 1875, section 47, states that pigs must not be kept in towns so as to be a nuisance; and the Public Health Act, London, 1891, section 17, prohibits pigs being kept in the Metropolis, so as to be either a nuisance or within 40 feet of a street.

The Bombay Act 3 of 1888, section 384, sub-section (1), clause (a), states that no person shall without the written permission of the Commissioner, or otherwise than in conformity with the terms of such permission, keep any swine in any part of the city; and the same section, sub-section (2), says that any swine found straying may be forthwith destroyed and the carcass thereof disposed of as the Commissioner shall direct, and no claim for compensation shall lie for any swine so destroyed.

The offensive odour from ill-constructed and badly kept piggeries is capable of travelling very considerable distances with the wind. The manner of preparation and storage of

the food for pigs may be a source of nuisance. It is exceptional to feed pigs upon sweet food; they are generally given refuse material of all sorts in which frequently fermentation has already commenced. If, as is sometimes done, this food is boiled, a greater nuisance than ever may arise.

In every case pig-sties should be situated at a considerable distance from any dwelling house, and not nearer than 100 feet from any well, spring, or stream of water used or likely to be used by man for drinking purposes or for domestic purposes, or otherwise in such a position as to render any such water liable to pollution.

The sty should have a smooth impervious floor of concrete or of Indian patent stone, properly sloped and provided with channels leading to a trapped drain inlet. If walls are built, they should be of brick or masonry rendered smooth inside with cement or patent stone so as to permit of being readily washed. The sty should be provided with a roof which, if resting directly upon the walls, should have a window in it to provide light and facilitate cleansing.

Under no circumstances must woodwork be permitted in situations where it is liable even to the slightest pollution. The sty should be washed regularly once a day at least. If proper attention is paid to the construction and the cleanliness of pig-sties, there is no reason why pigs cannot be kept without becoming a nuisance. On the other hand, if there is neglect their presence becomes intolerable.

SLAUGHTER HOUSES.

Slaughter-houses for killing cattle for food have been in existence in India from its earliest days. The ancient Aryans had slaughter-houses where cows and buffaloes and bulls were killed, but no description of the situation and construction of a slaughter-house or of the conditions under which they existed in those primitive times is available. They were said to be in the open country away from dwelling houses. Centuries have done nothing, however, to improve their conditions and so we find the practice of killing cattle

in villages and even in small provincial towns in the open or at best in an open shed. In Presidency and other large towns, Municipalities have provided slaughter-houses, but they are far below the modern standards of public abattoirs in the European continent and British Isles, and they are not laid out and constructed on proper sanitary basis.

The site for the location of a slaughter-yard and house must be carefully selected. It should be situated on slightly elevated land for facilitation of drainage and outside the town, though not very far away for convenience of transport of meat to the markets in the town. It would be advantageous to have the site for a slaughter-house situated within short distance of a railway line or a harbour to which it should be connected so that the animals may be brought directly into the slaughter-yard. The prevailing wind must be duly considered. Further, the locality must be such that the slaughtering of animals should be visible to none except to those who are carrying on the work, and the noises of cattle audible to as few as possible. All public abattoirs should be under the control of Municipal authorities; there should be, as far as possible, no private slaughter-houses; all facilities and conveniences should be extended to butchers and cattle dealers; in the event of a butchers' guild or company wishing to establish a slaughter-house, permission may be granted, provided they give the requisite guarantee for the judicious management of the same and are answerable to local authority. The advantages to the public from the provision of slaughter-houses maintained under the control and supervision of Corporations are many. (1) Meat injurious to health is prevented from being offered for sale. All meat unfit for food is destroyed; and meat of doubtful quality, but not unfit may be offered for sale after "declaration of quality." (2) In properly constructed slaughter-houses, fitted with the newest machines and appliances, slaughtering is conducted with cleanliness and expedition. It is also convenient and cheaper for licensed

butchers to kill their animals at such slaughter-houses and it inspires confidence in the public to patronise such butchers. (3) The pollution of earth, water and air, and in India of the meat, caused by careless management in private slaughter-houses is entirely removed. (4) The torture of animals is done away with as the necessary apparatus and arrangements for the stunning and stupefaction of animals are provided. (5) The animals brought for slaughter are regularly inspected, while those suffering from infectious diseases are killed and their bodies destroyed by incineration. Thus the spread of infectious disease among animals is efficiently prevented. The condemned meat is also destroyed. In connection with slaughter-houses there should be a spacious cattle yard, where animals may be purchased by butchers from cattle dealers. The yard should, if possible, be covered over with turf and provision made for the conservancy of the same and daily removal of all refuse and dung. Lairage accommodation in properly constructed sheds should be provided, where animals may have rest before slaughter, as only after sufficient rest of the body they furnish sound and normal meat; it is well-known that fatigue impoverishes the meat. The lairage stalls or pens should not be too large, so that in case of infectious disease the infection may be limited and disinfection rendered more easy. It is, therefore, necessary that the floors of the lairage stalls should be properly paved and made water-tight and drained. The walls, too, should be rendered smooth and non-absorbent, impervious to a sufficient height above the height of the animals, and the corners rounded off. No animal with any suspicion of infectious disease should be allowed into the cattle yard or the lairs. Sufficiently large and commodious inspection-sheds should be provided. They may be open on all sides, but should be properly paved and drained.

In connection with the inspection-sheds, there should be a properly equipped laboratory. The cattle yard, inspection-sheds, lairage-sheds and waiting-pens should be entirely

divided off by a high masonry wall from the slaughter-house proper, so that the animals awaiting slaughter may not witness the slaughtering of their comrades. In many slaughter-houses, the waiting-pens are mere annexes whence the animals witness the slaughtering and, even on account of faulty drainage arrangements, blood of the slaughtered flows to their very noses. The animals awaiting slaughter should be spared, as far as possible, any contact with sight or smell of the slaughter-house itself.

There is another economic value in entirely keeping apart animals awaiting slaughter, as it appears to be a well-established fact that the flesh of an animal killed in a state of fear or excitement loses some of its palatable and marketable qualities ; above all, humanity demands that they should be spared the painful sights and cries. The common practice of depositing blood barrels, freshly removed hides or offal and refuse from slaughter-houses in close proximity to waiting pens should be strictly prohibited.

In designing a slaughter house several points have to be duly considered. It should be sufficiently large and commodious to meet the special demands of the town population, whose needs it intends to supply. Slaughter-houses are built in different countries either under the separate or block system, the former also called French and the latter German.

The first (French) is built on the principle of providing each butcher with a room for himself in which to kill. These rooms lie on each side of a central passage which has a door at each end. Every small room has a door into this passage and another leading directly outside the abattoir. The characteristic of the French system is that each building is isolated and surrounded by an open space. In the larger towns where butchers are divided into butchers proper and salesmen, this system works very well ; it is the more expensive of the two. In the block system (German), all

the buildings of a slaughter-house are under one roof or, if a little away from it, connected with it by covered passages. The block system is not suitable to India, as there will be no free air-space around the building. The separate system is the best adapted for this country. The buildings in the slaughter-yard must be arranged so as not merely to be suitable for the actual number of inhabitants in the town, but also with a view to their increase, so that extensions can easily be made. The slaughter-yard must therefore be extensive. The following principles were given for the erection of the public slaughter-house of Bromberg. The area of ground must be at least 6½ sq. ft. per inhabitant in towns of 3,000 inhabitants; 5½ sq. ft. per inhabitant for towns of from 3,000 to 5,000 inhabitants; 4½ sq. ft. per inhabitant for towns of from 5,000 to 7,000 ; 4 sq. ft. per inhabitant for towns of 7,000 and more. From 7,000 to 10,000, 3½ sq. ft.; 10,000 to 50,000 3 sq. ft. over this figure 2½ sq. ft.

The abattoir or killing-house should be of solid, substantial material and should be up-to-date. The material used for the building, walls and floors must be durable and impervious and non-absorbent. The internal surface of the walls, to a height of at least 10 feet, with corners rounded off, must be rendered smooth and water-tight, so that it may be daily washed down with a hose. It is best to paint the inner surface with white oil-paint, as the same would show off dirt and will help to a considerable degree to reflect better light; if expense is not of much consideration, the internal surface of the wall may be fitted up with white, glazed tiles or even marble slabs. The floors of the slaughter-house and room for cleaning utensils, etc., must be hard and water-tight and must be sloped all round, having a drain at the lowest point discharging into a gully and trap to prevent gases from drains escaping and penetrating into the slaughter-house. The floors must be such as to resist being broken or cracked by the falling of

heavy objects or with the stamping of animals. They should not be smooth and slippery. They may be rendered on the herring-fish bone pattern, so that they can be easily washed and cleansed. The corners in walls and floors must be rounded off to prevent the collection of dirt and dust. The slaughter-house should be properly ventilated and lighted by doors, windows and sky-lights. The doors and windows should be provided, in addition to the ordinary shutters, with "fly-proof shutters" and they must be so fixed as to work automatically unless otherwise prevented. The sills of windows must be at least 5 ft. 9 inches above the floor. The doors and windows must be so arranged that the public cannot see into the slaughter-house. In connection with the slaughter-yard, a provision should be made also for a manure-house, offal-house, water-closets, disinfecting accommodation *boiler-house, a cold room, a cooling room, lavatories for* butchers and their assistants and, if possible, an incinerator and refrigerator and sterilizer. Besides these, there should be offices and dwellings for officials and the inspecting staff. The slaughter-yard and house should be provided with a plentiful good water-supply. The drainage should be on the most modern lines and the sewage treated biologically before being discharged into the sea, river or on land.

The blood which flows out at killing must be caught in vessels kept in the slaughter-house for that purpose, so that the floor may be soiled as little as possible and not rendered slippery. Blood when required for preparation of sausages must be collected in thoroughly clean and air-tight receptacles. All blood not so used should be boiled down in the shed provided for the same and used as manure.

All entrails must be cleaned in the offal-house. The walls of this house should be very clean, made of marble or glazed brick or tile. The floor also should be of good gradient and made of the same material. The house should have a plentiful supply of water and the offal refuse removed daily as soon as the slaughter-house is cleansed. The offal-house

must be daily washed down. Expert advice should be obtained for the provision of machinery, hoists, cranes, stunning machines and other appliances needed for the slaughter-house. They should be of the latest pattern.

In India the practice of slaughtering is ritualistic; it is not unlike the practice which obtains among the Jews all over the world. The bulk of the meat-eating population is Mahomedan and in almost all places the butchers belong to that religion. According to their ritual, the process of slaughtering serves to render the slaughtered animal *halal*, *i.e.*, partly a sacrifice and partly a ritualistic offering. The animal is not stunned, but bound and knocked over and the butcher cuts the neck transversely just below the lower jaw giving a clean sweep from ear to ear, cutting all the chief arteries and veins of the neck right down to the spinal column. There is no question as to the cruelty meted out to the dumb animal, as this could be obviated by rendering the animal unconscious by a stupefying blow, as some three or four minutes must elapse before the cutting process is begun and more before it is completed. The animal will thus be saved the lengthened period of unnecessary torment, thus avoiding the injuries and wounds of all sorts caused by the "throe" or death struggles. Humanity demands that this should be so. One often has seen Mahomedan *shikarees* making the *halal* after an animal or wild-fowl is knocked and rendered unconscious by a gun-shot. The Jewish method of killing does not rest on any command of God, that is to say, has no Biblical foundation but is authorised as a command of the Talmud by a number of learned Rabbis. If this matter is properly explained to the butchers and others, there is no doubt the demand of humanity will prevail and animals will be spared the cruel process now in force.

In India fresh pork-meat is a luxury occasionally indulged in by Christians and a few of the Chinese. In Bombay there are no public slaughter-houses for pigs, but only private under the Corporation surveillance and license. Only 2 or 3 pigs are

slaughtered a day. The scalding and the scraping of hair is done in the room where the animal is slaughtered. The animal is not stunned before killing. It is not understood why this should not be in the case of pigs, as the butchers are all Christians, and consumers would rather prefer the animals rendered unconscious before they are slaughtered.

The plan attached is of a model slaughter-house built in H. M. Dockyard, Chatham.

GLUE-MAKING.

Glue is obtained by boiling bones, hoofs, horns, scraps of skin, leather and waste animal matter in general. The materials are first limed and then washed in water to remove the lime. They are then boiled, the fat which rises to the surface being skimmed off, and the liquid glue underneath is run off into shallow moulds and allowed to solidify.

The accumulation of materials of the trade may cause some nuisance; this can be lessened by liming the layers of materials in the stacks and by taking particular care to see that they are kept dry.

The effluvium given off during the boiling process should be burned or condensed in water and in either case finally discharged *via* a high chimney. The scutch or debris which is left in the vat after the glue has been run off should be removed from the premises as soon as possible; otherwise much nuisance must arise.

GUT-SCRAPING.

The small intestines of pigs and sheep are cleansed and then soaked in water for a few days to soften. They are then scraped on a bench until practically nothing but peritoneal covering is left. They are then placed in water again.

The subsequent treatment varies according to whether it is desired to make sausage skins or catgut. If the former,

the guts are simply placed in salt solution; if, however, catgut is desired, they are treated with sodium carbonate and are then spun and finally bleached with sulphur fumes and dried. The trade, if improperly carried out, is a most offensive one, but it need not necessarily be so. The premises should be well constructed, lighted and ventilated. As large amounts of water are used, the floor should be of concrete properly sloped and drained. The walls to a height of at least six feet must be rendered with some smooth impermeable material, *e.g.*, concrete or Indian patent stone. The tables on which the guts are scraped must not be of wood but be made of stone. The guts should be stored in impermeable receptacles; wooden tubs should not be used. The waste liquids before being passed into the drains should be deodorised by chlorine water. It is of the utmost importance that a high degree of cleanliness be maintained as, if this be the case, no nuisance should arise. For other precautions against nuisance, reference should be made to the introductory remarks on this section.

FAT MELTING.

The chief substances used are beef, mutton and pig fat kitchen waste, waste meat and the materials obtained from boiling bones and scraps at knackeries and glue works. The degree of nuisance caused by fat melting depends largely on the freshness or otherwise of the fats, and on the means employed for melting. There are three methods which can be employed, *viz.*, open fires, free steam either with or without the use of sulphuric acid, and lastly steam jacketed pans.

The fresher the fats are, the less the nuisance. Unquestionably the most objectionable method of melting is that where an open fire is used, and generally speaking, the higher the temperature the greater the degree of nuisance. If done over open fires, the melting should be carried out at the lowest temperature possible, and suitable appliances

should be used for conducting away the fumes generated. By far the best method is to use steam, either free steam or steam jacketed pans. The advantages are obvious: the fat is not in direct contact with the fire, thereby lessening greatly the risk of nuisance; the fumes are collected and burned and, finally, the fat is easily run off into suitable receptacles in a simple and cleanly manner, so avoiding a frequent cause of complaint, *viz.*, the fouling of the surroundings which occurs in the process of removing the melted fat from the pans to the cooling receptacles. Under no circumstances should an establishment for the melting of fat be permitted to be erected in a populous neighbourhood, unless it is worked by steam. The other requirements of a fat-melting works have already been detailed in the introductory remarks. Particular attention should be paid to the provision made for the storage of fat prior to melting. Covered metal receptacles should be insisted upon in every instance, as otherwise much nuisance may arise.

FELLMONGERING.

A fellmonger is one who receives the skins of sheep and prepares them for the leather dresser. Two classes of skins are received, *viz.*, fresh and dry imported foreign skins. The fresh ones are first of all cleansed from dirt by being beaten by a mallet and then soaked in water, after which they are limed either by placing them in a pit containing milk of lime or, as is more usual now, by applying cream of lime to the fleshy surface by a brush, the skins being afterwards folded with the fleshy surface inwards. They are now hung up to allow the wool to become loose and when this occurs, they go to the pulling house, where the wool is removed. They are now known as pelts, and are thrown into a pit containing milk of lime until they go to the leather dresser.

The foreign skins being dry and hard are softened by placing them in water for some hours. While damp, the skins are hung up in a fairly warm chamber, where a slight

superficial putrefaction takes place, enabling the wool to be readily pulled off. The skins are not limed. The subsequent treatment resembles that for fresh skins.

LEATHER DRESSING.

A leather dresser is one who receives pelts as well as horse, seal, calf and goats' skins. All these latter he treats as regards liming and scraping, etc., just as described under fellmongering.

Having received the pelts, etc., he subjects them to a process known as breaking, which consists in scraping the fleshy side with a curved knife so as to remove the connective tissue, &c. The parts removed are known as fleshings. The skins now go back into pits of lime of varying strength or varying periods. The next process is to wash out the lime, after which the skins are placed in a solution of puer which consists of dogs' dung. In this they remain for a period varying according to strength. They are now scraped and washed and pass to a mixture of bran and water known as drench. In some works no puer is used, the skins going direct into the drench.

The pelts are now ready for either tawing or tanning.

For tawing, the prepared pelts are placed in a barrel containing salt, alum, yolk of egg and water.

TANNING.

A tanner is one who receives raw hides and prepares and tans them. Occasionally, all the three trades are carried out in the same premises. The tanner receives three classes of hides, *viz.*, fresh, salted and dried.

Treatment of fresh hides.—The first process is liming in a series of pits of varying strength. To secure even action, the skins are drawn out daily and replaced. The hair is next removed. The hides are then washed in clear water and then the fleshings removed with a curved knife. Of the

strictly tanning process, the first part is called colouring: the skins suspended on poles are lowered several times daily into a pit containing old tan liquor. The object is to colour all the parts evenly. They now go to the tan pits, passing through pits of gradually increasing strength. The materials used are oak, mimosa, valonia, hemlock and chestnut. Salted hides are treated in the same way except that they are first soaked for a day or two to get rid of the salt. Dried hides are placed in water and afterwards beaten until they are soft. Both then undergo the same treatment as fresh hides.

The following is a short account of the processes carried out in the Bombay tanneries:—

The skins are washed in three or four changes of fresh water. They are then immersed in lime solution for 8 to 10 days, during which time they are turned each day so as to secure even action. The hides are now removed, washed and scraped with the curved knife already referred to. They are again washed and placed in another solution of lime for 3 to 4 days, removed, washed and again scraped. They are further washed and trampled under foot in order to render them pliable. The hides are then immersed in a bark solution for 10 to 12 days, the hides being turned daily. On removal they are again dressed with the knife. They are now put in a second bark-bath for a similar length of time and on removal dressed as before. They are now placed in the myrobalan bath for 3 days. On removal they are dried and, when all moisture has been extracted, they are oiled and hung up; when dry, they are rendered pliable by being beaten on large smooth stones, after which they are packed in bales ready for transport. The above is the method adopted for sheep and goat skins; for cow hides and other large skins there is an additional (third) bark-bath. The whole process takes 40 to 50 days and for large skins 60 to 70.

The sources of nuisance in the foregoing trades are as follows:—

(1) In the reception of the raw skins and imperfectly cured foreign hides and their transference from one place to another.

(2) The ammoniacal odour proceeding from a large number of skins painted with lime.

(3) The emptying and cleansing of the tanks where the skins are washed.

(4) The removal of waste lime from exhausted lime-pits.

(5) The process of puering and the discharge of waste puer and drenches, etc., into drains of untrapped or into open drains and streams.

(6) The drawing of skins from lime-pits.

In Bombay the chief nuisance appears to be due to lack of supervision and to the hopeless overcrowding of lime and tan tubs on the premises, as a result of which it is almost impossible to properly cleanse the premises.

The premises in which these trades are carried on must be well constructed. The floors should be of concrete, sloped and drained. The walls should be coated with cement to a height of about 8 feet. The pits must be made of a material which will not readily flake or wear away and the corners should be rounded off so as to facilitate cleansing. The entire process should be carried out in closed buildings lighted from the roof and well ventilated.

The water in the tanks where skins are cleansed should be changed daily. Waste lime and fleshings should be removed daily. Puering can be carried out using a cold solution although this method takes longer, and in any case it must be done in a closed chamber ventilated by a special shaft discharging well above the roof of the premises. In some works the waste puer and drenches are collected in a tank and allowed to settle and treated with lime before discharge into the drains. All waste tan material must be removed daily and it should on no account be burned on the premises, as this may cause great nuisance. The interior of the tannery, etc., should be lime-washed at frequent intervals. All tan tubs should be laid in regular parallel rows with a space of at least $2\frac{1}{2}$ feet between the rows to permit of proper daily cleansing; since this has been insisted upon in the local tanneries, much improvement has resulted.

Apart from nuisances, there are certain definite dangers in connection with these trades, *viz.*, infection with Anthrax, and lead, arsenic and mercurial poisoning.

Lead poisoning may arise from the fact that oxide and other salts of lead are used in the preparation of certain forms of leather. *Arsenical poisoning* may arise owing to arsenical salts being used to preserve the skins during transit or to their use in the treatment of certain varieties of skins. *Mercurial poisoning* may arise from the same cause.

Skins treated with a mixture of lime and orpiment may on washing cause the water to give off sulphuretted hydrogen gas, leading to the formation of arsenious acid and sulphurous acid.

Anthrax may arise from handling infected hides from Russia, Persia, Turkey and India. The infection may result from inoculation through the skin *via* a wound, or from inhalation or from swallowing the bacillus.

Much attention has been paid to this subject, and Seymour Jones has brought out a process for dealing with hides to lessen the risk of this disease. A disinfectant to deal with hides must be capable of destroying the spores of Bac. anthracis when present on hides and skins under any of the conditions in which they may be supposed to occur naturally, *e.g.*, when protected by hard, dried blood. It must not injure the hide nor interfere with any of the subsequent processes by which they are converted into leather. It must be simple, cheap, and non-dangerous or non-poisonous to those who have to carry out the disinfection.

His process consists in placing the dry hides for 24 hours in a soak, which is made up to contain 1-2 per cent. of formic acid and ·02 per cent. of perchloride of mercury, and then salting them with sodium chloride. The action of the soak is to swell up the fibres of the hide by causing them to absorb water, the result being that the hide returns to a condition closely resembling that in which it was when taken from the

animal carcass. This swelling action also affects the dry albuminous matter which may be supposed to protect the spores and permits of the action of perchloride of mercury. After the soak the salt, by again abstracting water, converts the hides into a condition which differs very little from the wet salted state of a hide, which had been so treated immediately after flaying.

It is claimed for this process that no damage is done to the goods, that the process is simple and can easily be carried out at the port of shipment by unskilled labour, that it is cheap and that there is no danger in using perchloride in the required dilutions, the goods requiring very little handling.

Storage and pressing of hides.—Fresh skins after being beaten, soaked and washed are salted and sometimes treated with a mixture of lime and orpiment and then dried. In the subsequent handling of these skins, either loose or in bales, there is a considerable amount of disagreeable smell and dust evolved. This dust has been shown to contain arsenic. For these two reasons it is not desirable to have hide depots located in or near thickly populated parts of a city.

SOAP-MAKING.

Soap is prepared by the combination of an alkali either soda or potash with fat or oil. The glycerine or the base of the fat is displaced and is replaced by the alkali forming soap.

Soaps are divided into two classes, "hard" and "soft". according to their physical characters. Hard soap is made with soda while soft soap has potash for its base.

Various fats and oils are used in preparing soap. The interest of the sanitarian in the process of soap-making lies not so much in the soap itself as in the fats and oils from which it is made and the storage and boiling of which often causes nuisance.

Soap is prepared either by the cold process or by the boiling method. In the former, the fat or oil or both are

heated to about 120°F. and then the cold solution of potash or soda called "the lye" is introduced. The whole mass is thoroughly mixed and the soap is run into frames where it sets into solid sheets. Bars or blocks are cut from this as desired.

In the boiling process, the fat or oil or both are boiled in large pans either on an open fire or better by steam discharged into the interior of the pans at the bottom or into a steam jacket around the pan. Caustic "lye" is gradually added until the materials have been introduced in proper proportions to form soap. The rest of the method is the same as in the cold process.

The chief offensiveness in soap-making arises from the manipulations of fats and oils. The fats may be stored too long on the premises in uncovered vessels or fragments of animal or other matter may be lying about on the floor. Nuisance may arise from the vapours and gases emitted during the process of boiling or from the waste liquor if this is not disposed off properly.

To obviate these nuisances, the following conditions are enforced in Bombay :—

1. Floors and walls upto a height of 6 feet, of building used for soap-making to be rendered impervious and smooth.
2. Premises to be cleaned every day.
3. A sufficient number of receptacles constructed in galvanised iron with tight fitting lids to be provided and all refuse fragments of animal or other matter which have fallen about the premises, to be deposited in them. These receptacles are to be cleaned daily.
4. All refuse to be removed from the premises daily to a place appointed for the reception of such material.
5. The interior and exterior of boiling pans, casks, tanks, vats, troughs, etc., to be cleaned up as often as is necessary to prevent accumulation of filth.
6. Materials not required for immediate use to be stored in such a way as to prevent emission of injurious effluvia therefrom.
7. Best practicable means to be used to render innocuous all gases and vapours given off during the process of soap-making.

8. Repairs to walls to be undertaken when necessary and lime-washing of building twice a year or oftener if required.
9. Means of drainage and ventilation to be maintained in good order.
10. Any building in which soap is stored, not to be used for human habitation.

MANUFACTURE OF COW-DUNG CAKES.

This trade is carried on by a certain class of people. Dung mixed with waste straw is collected from stables and circular cakes, pressed by hand, are prepared from it. These are then spread over any open plot of land and left exposed to the sun for drying. They are removed in about a week after one or two turnings. The poorer class of people use them as fuel and they are also in demand by Goldsmiths and Jewellers for their trade.

The trade is an offensive one as the collection of dung and the preparation of cakes are all done by hand. A sufficient quantity of dung is collected before it is made into cakes and as such collection takes time, the smell given off during the interval from the decomposition of dung-heap causes serious nuisance to the neighbourhood. The dung-heap serves also as a breeding place for flies which deposit their eggs in it. When the cakes are made and exposed for drying, the larvæ which hatch out from the eggs burrow into the soil to complete their development there.

The trade should not be allowed to be carried on in any place unless it is open on all sides and situated at a sufficient distance from any dwelling house, workplace, etc. Dung should not be allowed to accumulate for more than 24 hours. The trade should be licensed and the conditions of the license strictly enforced.

FERRO-SILICON: ITS USES AND DANGERS.

Ferro-silicon is an alloy of iron and silicon used in the manufacture of steel. Its transport has occasioned many deaths. As its use is spreading and as steel and iron works

are springing up in India, these few notes as to its dangers are inserted. It forms an essential ingredient as regards its silicon in the manufacture of certain grades of steel, to which it is added in small quantities while the metal is in a molten condition. Silicon has a high calorific value and acts as a metallurgical fuel; hence by causing molten steel to remain fluid for a long time, it enables thin and intricate castings to be made and by reducing action it prevents the formation of blow-holes in castings. The addition of silicon to steel imparts to it, among other valuable physical properties, a high tensile strength when present to the extent of rather less than 1 per cent. together with small quantities of carbon and manganese. The low grade variety, containing not more than 15 per cent. of silicon, is made in blast furnaces to a considerable extent, while the higher grades are made in the electric furnace.

Dangers in connection with transport and storage.—High grade ferro-silicon is liable to evolve gases of a deadly nature when brought into contact with water, or even when exposed to the action of moist air. This dangerous tendency is more especially referable to certain grades of it, especially those averaging a content of between 30 and 70 per cent. silicon; and some of these grades show the curious physical property of spontaneous disintegration, the lumps of which they consist being found to be liable to crumble during transport and in some instances to actually fall to powder, thus presenting a large surface to the action of a moist atmosphere with consequent greater evolution of poisonous gases. A careful examination of a large number of samples has shown that this tendency is confined more especially to the middle grades.

Manufacture.—A mixture of steel turning with quartz and coal is put in an electric furnace and heated.

Impurities.—Certain impurities originally present in the coal, iron and quartz used, or formed from them during the

process of manufacture, are always present, and some of these are the ultimate cause of the accidents which have occurred. Calcium phosphate $Ca_3(Po_4)$, one of the impurities present in coal and in quartz, in itself harmless and widely diffused in nature, is responsible for the production of calcium phosphide, which remains in the ferro-silicon and in contact with water or moist air is decomposed with the evolution of phosphate of hydrogen (PH_3). Arsenic is another impurity liable to be present in various combinations in coal and in iron, and this is present in ferro-silicon apparently as calcium arsenide which is also decomposed by water or moist air, evolving arseniuretted hydrogen (AsH_3), a gas scarcely if at all, less poisonous than PH_3.

Acetylene was formerly found as an impurity, but this was probably due to the fact that the furnaces used for the manufacture of ferro-silicon were also used for making calcium carbide. Siliciuretted hydrogen has also been suggested as an impurity liable to cause poisoning; but on contact with moist air, this gas splits up into silica and hydrogen.

The poisonous emanations from ferro-silicon on contact with water consist mainly of phosphoretted hydrogen, sometimes alone but for the most part accompanied by varying proportions of AsH_3. These two gases are deadly poisons, and among the symptoms, common to both, produced by their inhalation are severe abdominal pains, nausea, vomiting, great weakness and prostration, gradual loss of consciousness and death frequently within 24 hours. Among other signs, etc., are cold, clammy sweat, pulse almost imperceptible, breathing slow and light, crepitations in the lungs, and pupils somewhat dilated. Phosphoretted hydrogen has been proved by experiments to be fatal to animals when present in the air in the small proportion of 0·025 per cent., and so far as experience goes AsH_3 is scarcely less poisonous.

The various grades have been classified into three groups :—

Class 1 :—10 to 30 per cent. silicon, containing practically no poisonous impurities and not liable to spontaneous disintegration.

Class 2 :—70 to 90 per cent. of silicon, not entirely free from poisonous impurities but not liable to disintegrate.

Class 3 :—35 to 60 per cent. silicon, containing in most instances a considerable proportion of poisonous properties and in addition being more or less liable to disintegration.

The volume of gas given off varies, and Hake found that certain low grades yield on an average 0·2 cubic foot per ton while certain high grades yield 2·1 to 5·7 cubic feet, and the intermediate grades containing from 42 to 52 per cent. of silicon yield the largest amount, *viz.*, 2·1 to 16·8.

It will thus be seen that the atmosphere of a cabin on boardship might, under certain circumstances, very rapidly assume a toxic character, if ferro-silicon forms a part of the cargo. One of the conclusions arrived at by D. Copeman is that low grade ferro-silicon (10 to 15 per cent.) does not evolve poisonous gases even in the presence of moisture. Ferro-silicon of all grades up to and including 30 per cent. appears to be practically innocuous, and this applies probably to those above 70 per cent. though in a considerably less degree. The proprietors of iron and steel works are therefore advised to restrict their orders to grades of this material either not exceeding 30 per cent. or 70 per cent. and upwards, according to the special nature of their requirements. Copeman and Hake are therefore in accord in their experiments and findings.

REGULATIONS RECOMMENDED.

1. Ferro-silicon should not be sent out of the works immediately after manufacture, but, after being broken up into pieces of the size in which it is usually sold, should be stored under cover, and exposed to the air as completely as possible for at least a month before being despatched from the works.

2. Manufacturers should be required to mark in bold letters each barrel or other parcel of ferro-silicon with the name and percentage grade of the material, the name of the works, the date of manufacture and the date of despatch.

3. Its carriage on passenger vessels should be prohibited. When carried on cargo boats, it should, if circumstances permit, be stored on deck. If considered necessary to store it elsewhere, the place of storage must be well-ventilated and be cut off by air-tight bulkheads from the quarters occupied by the crew. This is to apply to river and canal boats. Storage places at docks, or at works where ferro-silicon is used, must be well ventilated and away from workrooms, mess-rooms and offices.

PAPER-MAKING.

Paper consists of cellulose fibres matted or felted in a sheet and is usually prepared from a variety of raw materials such as old rags, straw, hemp, flax, jute, wood and esparto-grass. The first step in the process is the preparation of the pulp and it is in connection with this that nuisance mostly arises.

Rags are prepared primarily by being dusted in an "Agitator." They are then cut into small pieces and again dusted; after which they are boiled with Carbonate of soda or Caustic soda or a mixture of both. Next they are bleached either by chlorine in a closed chamber or by the alternate application of bleaching liquid and acid. Their subsequent treatment is the same as that of wood pulp or esparto-grass.

Wood-pulp is prepared by cutting the wood into fine chips and then boiling them with Caustic soda under pressure.

Pulp from esparto-grass is prepared in a similar way. The grass is cleaned by picking out the impurities from it and then boiled with a caustic alkali in a closed boiler into which steam is forced under pressure. The liquor is very foul and is either discharged into drains or run into a store tank. From this by subsequent evaporation and incineration of the residue, soda is recovered which makes this an economic operation of some value.

From pulp obtained from rags, wood or esparto-grass, paper is prepared by a series of mechanical procedures which do not involve sanitary questions.

The sources of nuisance in the foregoing trade are as follows :—

The collection and storage of old rags and waste material of a similar kind is a constant source of danger to public health. The vapours given off during the processes of boiling and while the pulp is cooling down are very annoying and evoke a large number of complaints from the residents in the neighbourhood. The esparto liquid is a serious source of nuisance. It resembles strong tea in colour, is alkaline, strongly reducing and is offensive in odour. Lastly the process of recovery of soda leads to even greater nuisance partly from vapours yielded by the evaporation but still more from the pungent fumes produced by the ignition of the residue.

In order to minimise the nuisances in this trade, the following precautions should be observed :—

All vapours should be conducted by a flue into a tall chimney and discharged high into the atmosphere. The discharge of waste liquor into drains, while it is hot, should be prohibited. It should be cooled in settling tanks and subsequently filtered through earth or ashes. The fumes produced during incineration should be burnt in the furnace fires.

SUGAR REFINING AND SUGAR REFINERIES.

Sugar is largely adulterated by mixing it with inferior or impure kinds of sugar. Impure sugars are dark in colour, imperfectly crystallized, heavy and clammy, and readily cake into masses. They are found to contain fragments of cane, and woody fibre grit. Sugar is also adulterated with starch with a view to improving its colour, and with water of the treacle or molasses. Hence there is a large business

carried on in India which is known as 'refining sugar,' and the manufacture of sugar-candy or *khuri-sukkur* and finely powdered sugar or *pithi-sukkur.*

The process of sugar refining in India differs from the methods employed in Europe. The modern methods of refining as carried out in Europe are to dissolve the raw sugar, treat it with lime, and then clarify and filter it. It is then decolorized by mixing it with animal charcoal or bone-black and filtered again. The result is a clear, transparent, slightly yellow fluid to which a trace of ultra-marine blue is added. It is now transferred to a vacuum-pan and evaporated until it is of sufficient density to crystallize, and then centrifugalised.

The sugars used for refining in India are: (*a*) Mauritius No. I., (*b*) Java No. I., and (*c*) the English beet-sugar.

The basis of the process in India is to treat the syrup with milk and water with a view to removing the impurities. The sugar is dissolved in hot water in a large vat placed over a furnace and heated to the boiling-point, the mixture being constantly stirred so as to prevent the sugar from being charred. The proportion of water used is about five gallons for every bag of sugar weighing six maunds. When the mixture of sugar and water attains the boiling-point, milk mixed with water in the proportion of five parts to one is gradually put into the boiling syrup. The effect of this is to cause a scum to appear on the surface together with particles of dirt. Cold water is then added from time to time so as not to overboil the syrup until all the dirt rises to the surface.

The next procedure is to remove the scum by means of flat, perforated iron spoons and to set it aside for further treatment. The clear syrup is next stored in large galvanized zinc or copper tubs fitted with stop-cocks. When sufficient syrup is collected, the cold syrup is drained off through the taps into flat-bottomed pans, and placed over a small fire-

place and allowed to boil until it attains a certain amount of consistency. This is next poured into a flat iron-tray and kept to cool for a period of seven days, when it solidifies in layers. The solidification is complete at the bottom, above this is a layer of treacle or molasses, and the topmost layer consists of crystallised sugar.

At the end of seven days, a hole is pierced into the upper or crystallised layer, and the trays are kept in a slanting position over a sloped staging of galvanized iron so as to drain off the treacle or molasses. This treacle flows into a tray and is kept for further treatment. When all the treacle has been drained off, the trays are removed and the crystals of sugar collected over a mat, while the solidified layer at the bottom is broken up into small pieces. The sugar-candy is then sieved so as to remove the finer particles and sorted into four sizes. The sugar-candy thus produced is of a white colour.

The treacle which is drained off the trays is further boiled in flat-bottomed pans over an open fire-place, and constantly stirred until it attains the required consistency, when it is put into pans and allowed to cool for some days. It then solidifies into three layers in the same way as described above and when cooled, the same process of piercing a hole into the upper crystallised layer and draining off the treacle into pans is repeated. In this second process, as the treacle is further heated, a certain amount of browning of sugar takes place, and hence the sugar-candy is of a brown colour somewhat resembling toffee.

The treacle that remains from this second boiling is further heated in an iron pan over an open fire-place until it attains a certain amount of consistency, when it is poured into buckets and formed into a substance called "*goor*."

The scum or dirt, which is removed and set aside in the first part of the process of refining sugar, is then mixed with water in varying proportions and boiled to the boiling-point.

It is then sieved in a basket covered with cloth and the liquor is used to make *goor*, in the manner described above.

The liquor or uncrystallisable solution of sugar and the scum or dirt is also sold to tobacconists to make *guracco*, *i.e.*, tobacco sweetened with molasses.

Pithi sukkur is made in the same way as sugar-candy except that, instead of allowing the thick syrup to solidify or crystallise, it is removed from the pan and macerated by a wooden spoon until the syrup is triturated into a mass resembling flour.

This trade is an offensive one, and it should therefore not be permitted in crowded areas. The sources of nuisance are the following :—

(*a*) In the process of boiling the sugar, very offensive odours are given off which pervade the neighbourhood for some distance.

(*b*) The smoke, if there is no proper flue and chimney, is allowed to escape through windows or doors or gratings in the roof, and thus causes nuisance to the neighbouring residents.

(*c*) Flies are attracted in large numbers owing to the storage of sugar on the premises.

It is necessary in the public interest that this trade should be carried on under wholesome conditions, and for that purpose the following requirements should be demanded :—

(1) The building in which this trade is carried on should preferably be a ground-floor structure. It should be well ventilated and should not be used for residential purposes.

(2) The floor should be paved with smooth stone or tiles, so as to be readily cleaned and washed.

(3) There must be a proper flue and chimney to conduct the smoke and fumes from all the furnaces. The chimney should be carried above the eaves of neighbouring buildings. For this purpose, it is recommended to build furnaces with chimneys on the lines of the kitchen "copper" used in England.

(4) The fuel used in the furnaces should preferably be coke, instead of firewood or coal.

SILVER SMELTING, CASTING METALS, ETC.

These trades, as carried on in India, may be classified as under :—

(1) Casting of the metals, iron, lead and copper, and the casting of brass. This latter consists of an alloy of copper and zinc in the proportion of 2 of copper to 1 of zinc. It is harder than copper and can be more easily worked and for most purposes its quality is considerably improved by the addition of 1 to 2 per cent. of lead.

(2) Melting and refining of silver.

(3) Extraction of silver and gold from embroidery.

(4) Silver-wire-drawing.

(5) Working in gold and silver for ornaments and jewellery.

(6) Working in copper, brass, tin, aluminium for the making of household utensils, etc.

Each of these trades will now be described in detail.

I.—CASTING OF THE HEAVY METALS, IRON, LEAD, COPPER AND CASTING OF BRASS.

In large works, with few exceptions, furnaces protected by a hood and provided with a chimney are used. The fuel employed consists of coal and coke.

In some of the places, in addition to the casting of metals a workshop is provided which results in further vitiation of the air by the addition of minute particles of metal. The majority of these works are carried on on the ground-floor of houses used for human habitation, in rooms where the means of ventilation are very defective, and where the cubic air-space available is not sufficient to dilute the products of ordinary combustion, the amount of which depends upon the degree of perfection of combustion. In smaller works specially constructed shallow furnaces are used, the fuel being the same as in larger works.

It must be understood that in none of these works is smelting, in its ordinary sense, carried on. The metals are simply melted and cast for purposes of commerce and no ores are treated.

II.—MELTING OF SILVER.

Old jewellery, silver coins, etc., are melted in furnaces in which a very high temperature is reached. Where large quantities are dealt with, iron hoods and a chimney are provided to carry off the gases formed. Many of these hoods and chimneys are, from faulty construction, practically useless to prevent the fumes escaping into the shop, and those that do succeed in this, do so at the expense of the neighbours, as the chimney terminates immediately outside the wall. In the smaller works, special shallow furnaces are used. These are provided with bellows to assist combustion. To purify the silver, it is treated with crude sal ammoniac or it is fused in a crucible with 5 per cent. borax and 5 per cent. sodium nitrate, and finally run into moulds.

III.—RECOVERY OF GOLD AND SILVER FROM EMBROIDERY.

There is a distinct body of men engaged in this trade (*Jarriwallas*). The process adopted by them is one which undoubtedly gives rise to considerable nuisance; if not indeed danger to health also. The following is an outline of the method. Old clothes and caps, etc., are bought and carefully sorted, and the embroidery removed and washed. This is now burnt and the ashes placed in a flask and a considerable quantity of almost pure nitric acid is added, and the whole gently heated over an open charcoal fire on the floor of the room. This causes evolution of dense, reddish, brown fumes of a very irritating character. These fumes are permitted to escape unchecked into the room. This operation is carried on until these reddish fumes cease to rise, after which the greenish blue liquid in the flask is poured off into a large basin. Fresh acid is now added to the deposit in the flask and the heating process is repeated until all the silver is

extracted. The residue or deposit left in the flask is put aside and, by a method to be described later, gold is recovered from it.

Now, from the solution of silver in nitric acid, the metal can be recovered by one or two or more processes. Two of these methods may be described.

(*a*) The solution is evaporated and the residue is dissolved in dilute ammonia, and the resulting blue solution is diluted with water to bring the strength of silver down to 2 per cent. A sufficient quantity of normal ammonium sulphite is now added to render the solution colourless on warming and the whole is allowed to stand for 24 hours, when one-third of the silver separates. If the supernatant solution is now heated to 60° or 70°, the remaining two-thirds of the silver separates out.

Or, (*b*) the solution of silver in nitric acid is placed in a large earthenware basin and small pieces of sheet copper are added to it. The silver then becomes deposited on the copper.

The deposit left in the flask after the extraction of the silver is heated in crucibles, and from it certain quantities of gold are recovered and run into moulds.

IV.—SILVER-WIRE-DRAWING.

Another industry is that of silver-wire-drawing. The silver is first covered with gold-leaf and is then heated in a small open furnace in which wood fuel is used. It is drawn cold.

The wires are drawn through gauges of varying calibre. Human labour is used throughout. The majority of premises in which wire-drawing is carried out appear to be used for that purpose only, but some carry on melting and casting as well.

V.—MANUFACTURE OF SILVER ORNAMENTS, JEWELLERY, ETC.

Silver used in the arts and for coinage is usually alloyed with a small amount of copper, which renders it more durable and more easily worked up. English coins and plate usually contain about 7·5 per cent. of copper. These premises do

not appear to cause any nuisance or injury to health to the surrounding inhabitants, in so far as production of vapours is concerned. Certain organic acids are used for cleansing purposes, but they do not appear to cause a nuisance.

VI.—WORKING IN COPPER, BRASS AND ALUMINIUM.

Here ornaments and articles for domestic use are manufactured. No nuisance is occasioned from injurious vapours as the articles are manufactured from sheets of various metals prepared elsewhere. Much noise from hammering, etc., arises.

GENERAL REMARKS.

In the vast majority of cases, the above mentioned processes are carried on on the ground-floor of houses used for habitation. These rooms are often dark and in almost every instance quite inadequately ventilated.

In the process of casting heavy metals, in addition to the products of combustion of the fuel used, large quantities of carbon monoxide and dioxide and the oxides of sulphur must be liberated; occasionally, all of these are permitted to escape directly into the room; and even in those instances where hoods and chimneys are provided, their efficiency in many cases is far from satisfactory.

The melting and refining of silver is carried on generally in rooms quite unsuited for the purpose, the floor being of mud or wood and the walls of wood occasionally. It has already been stated that some of the larger establishments have hoods and chimneys to convey the products of combustion away; but in many of these instances the object aimed at is not often attained; this being due to faulty construction and general disrepair. Another point which must be noted here is that in those cases, where a certain amount of success has attended the effort to convey the fumes away from the workshop, it is accompanied by a corresponding nuisance to the immediate neighbours, owing to the chimney terminating immediately after passing through

the wall. There is evidence also to show that, even where furnaces furnished with a hood, etc., are provided, work is carried on in the same room in furnaces not so protected. Owing to the use of coal and coke as sources of heat, large quantities of the oxides of carbon and sulphur must be evolved and, in the absence of adequate means to carry these products away, injury to health must result.

Undoubtedly, however, the greatest nuisance is occasioned by the *Jarriwalas* or those engaged in recovering gold and silver from old embroidery. Here the industry is carried on in small shops in crowded districts in rooms which have no through ventilation. The rooms are usually on the ground-floor of houses used for human habitation. The source of heat is open charcoal fires. The processes carried on result in dense volumes of irritating gases filling the room and escaping therefrom, occasioning nuisance in the neighbourhood. There are no properly constructed fire-places, the flasks are placed directly on a charcoal fire which is located on the floor, and which may or may not be in close opposition to the wall. No means of escape for the fumes other than the entrance to the shop, is provided.

Silver-wire-drawing in itself occasions no nuisance nor does the manufacture of articles for domestic use from copper, brass and aluminium. While it is, perhaps, desirable that many of these businesses should be removed to less populous districts in large cities, such a course would tend to dislocate the business of old established firms and would entail great hardship to owners and tenants alike. Such a drastic method could be obviated to a great extent by enforcing certain regulations for the conduct of the business. Such of the owners and tenants as are unwilling or unable to conform to these requirements should be refused a license and compelled to abandon the use of the premises for such a purpose. It is desirable also that no new business be allowed to be established in crowded areas.

It is not possible to frame regulations which would be applicable alike to all the premises used in these trades, and it is necessary therefore that each application for a license be considered on its merits, keeping in view, however, certain main principles directed towards the minimising of nuisance and danger to health of both of those engaged in the work and those living in the neighbourhood.

The following points should be considered in all applications for licenses for the purpose of carrying on the business of lead, iron, copper and brass casting; smelting and refining of silver; and recovery of silver and gold from embroidery:—

(1) None of these businesses should be permitted in rooms used for human habitation by day or night.

(2) The structure of the walls and floors should be such as not to present undue risk from fire.

(3) No workshop should be licensed unless provided with adequate *through ventilation*, by means of windows or gratings or both.

(4) No premises should be licensed unless provided with proper fireplaces or furnaces.

As far as possible, such workshops should be situated in premises not used for human habitation. The majority of workshops, however, are situated on the ground-floor of houses so used; where, therefore, more suitable accommodation is available, pressure should be brought on these to remove. Where, however, such is not the case, certain measures for the purpose of minimising the risk of nuisance should be insisted on, and no workshop used for these trades should be permitted in houses used for human habitation, unless for each furnace there is provided and applied *and used* a hood of sufficient size to collect the fumes arising; this hood to communicate directly with a chimney which may be of metal or other suitable material, and which must be of sufficient length to permit of the discharge of the fumes in such a

manner as to cause no nuisance. Further, it should be provided that the hood and chimney at all times be maintained in a good state of repair.

In no instance should the chimney be allowed to terminate in close proximity to a window.

In those cases where, from the situation of the premises or other cause, it is impossible to provide for the fumes to escape by means of a chimney discharging directly into the open air, provision should be made for the destruction of the gases by conducting them into or under a fire or by condensation in water. Where none of these methods or other suitable method is available, the premises should be considered unfit for the purpose.

Another method of obviating the nuisance from these smelteries is to keep the flasks in a brick chamber during the boiling operation. The chamber should be fitted with a chimney carried to a sufficient height to prevent any nuisance to the adjoining houses. The chamber may be built of ordinary bricks, as there is not sufficient heat given off by the charcoal to necessitate the use of fire-bricks.

PRESSING OF OIL SEEDS.

A very extensive trade in the extraction of oil from seeds is carried on in Bombay and other cities in India. *Til*, cocoanut, and ground-nut oils are the principal oils extracted. They are all edible oils and are largely used as substitutes for ghee.

For the most part very primitive and wasteful wooden presses are used, worked by a pair of bullocks working in turn, and driven by a man who sits on the press and feeds it from time to time with the material to be crushed. There is no inherent nuisance associated with the trade itself, but under the conditions in which it is carried on, much nuisance does result in practice. This is due to the fact that the great proportion of these oil-presses or *ghanis* are located on the ground-floor of inhabited houses. The rooms are

practically devoid of light and ventilation, except such as may be obtained through the door. The spare bullock or bullocks are generally stabled in a corner of the room, the floor of which is unpaved and undrained and generally maintained in a state of filth. As a rule, the workmen and their families also live in the room.

In many of the rooms, there is no through ventilation and the size thereof is so small as to occasion a considerable amount of cruelty to the animals.

The amount of oil extracted from *til* seed is about 40 per cent. and from cocoanut about 60 per cent. The solid residue is used for feeding animals.

To obviate the nuisance, the best measure is to adopt mechanical power in working the *ghani*, where the business is of such dimensions as to render such a change financially possible. Failing this, no license should be given to work an oil *ghani* by bullocks in a crowded neighbourhood or in any room of a dwelling house. Where bullocks are used, properly paved, drained and ventilated stabling accommodation should be insisted upon.

PARCHING OF RICE.

Parched rice or *Kurmura* is largely consumed by the poor, and also as "refreshments" by school children during the mid-day recess.

The process of making this article of food is generally carried on in a shed which contains several ovens, the number of the latter varying with the length of the shed.

The ovens are built of *kutcha* bricks and mud, and thickly smeared over with dung. They are circular in shape and have an opening on the top into which is fixed an iron pan of varying size. There are no chimneys, but at the back of each oven, there is a large slit, two feet in height and six inches in width, which acts as a kind of flue and also serves the purpose of feeding the fire.

The fuel used consists of the husks of rice, saw-dust and thin stalks of hay. As the fire is fed through the slits, an outward draught takes place, which brings out a good deal of smoke. In fact, when all the ovens are lighted, the smoke nuisance is considerable owing to the kind of fuel used.

The rice used is of very inferior quality. It is first soaked with the husks on it in boiling water in a wooden tub. This soaking lasts for 15 hours. Then the rice is sieved out by means of iron sieves, and placed in a smaller dry wooden tub, perforated with holes at the bottom, to allow of the water in the soaked grain to be completely drained off. The next process is to subject it to a partial baking in the iron pans placed at the top of the ovens. After this, the rice is placed on mats and allowed to dry in the sun. It is next threshed out in large wooden chalises by being beaten with thick sticks, at both ends of which are iron caps. When the husks are fully removed, the rice is treated with salt dissolved in water, and then it undergoes final baking in the iron pans on the ovens. This baking lasts for 3 hours and, in order to prevent the rice from being burnt, it is mixed with a certain proportion of sand.

There is no cleanliness observed in the whole process of making this parched rice; the tubs and other utensils are rarely cleaned before use. The shed in which this business is carried on is used for dwelling purposes as well, and great danger of contaminating this food arises when any cases of Cholera or Enteric Fever take place among the persons residing in this shed. They all sleep on the very floor where the rice is spread out and threshed, and this floor is made of earth smeared over with cow-dung.

This trade ought to be carried on in decent, well-ventilated sheds which should not be used for human habitation. The following requirements are now demanded:—

1. No place used for parching rice can be licensed if within a distance of 50 feet from any dwelling house.

2. The floors of bhatties should be consolidated. The sheds should be open on all sides.
3. A properly consolidated open space of sufficient size should be provided for exposing soaked grain to the sun.
4. Suitable vats or barrels should be provided for soaking the grain. Only Municipal pipe water should be used for this purpose. All well water forbidden.
5. As only cotton dust, rice husk, and occasionally sawdust is used for fuel and as any other fuel (on enquiry), has been found not convenient and serviceable for the industry, the furnaces should be deep with proper arrangements made for removal of ashes.
6. Sufficient water-closet accommodation should be provided. The number of seats to be determined by the number of men employed.
7. A proper washing place of sufficient size should be provided; it should be properly paved and drained and connected to the sewer.
8. Ash-bins of sufficient size should be provided and arrangements made for the disposal of ash.
9. The sheds should not be used for human habitation and the floors should be kept scrupulously clean.
10. All receptacles for storage of water should be of uniform pattern with proper fitting covers.

EATING-HOUSES.

There is a very large number of eating houses in Bombay and other cities in India. These places play an important part in the lives of the poorer working classes, and the low-paid and unmarried populace, for whom these houses for the most part cater, have to rely on them for their daily food. This fact alone is sufficient justification for demanding that a certain minimum standard of sanitation in regard to these eating houses should be compulsory.

By Act No. I of 1916 the "keeping of eating houses" has been included in the list of trades specified in Part IV of Schedule M of section 394 of the City of Bombay Municipal Act, and the following definition of the term "eating house" inserted in the Act—

"Eating-House" means "any premises to which the public are admitted and where any kind of food is prepared

or supplied for consumption on the premises for the profit or gain of any person owning or having an interest in or managing such premises."

It will not be out of place here to point out some of the most glaring defects that have been noticed in some of these poor class eating-houses and the remedies which are necessary to make them sanitary.

The houses were licensed by the Police, and such licenses were granted indiscriminately without reference to the suitability or otherwise of the place and its surroundings for the purpose of preparing food for human consumption.

In the majority of cases, there is but one eating-room or restaurant proper, which may or may not communicate directly or indirectly with the cook-room. Chiefly, however it does so directly, and in some instances performs the dual function. With a few creditable exceptions, the general impression in regard to those eating-rooms is one of filth everywhere—filth on the floor, filth on the walls and filth on the ceilings.

Some eating-rooms are used as sleeping apartments for those employed in the business or by the family of the proprietor. In the majority of instances, the floors are properly paved, but in some instances they are rammed with earth and smeared over with cow-dung. The importance of a clean floor is better appreciated when one remembers that many of the customers take their meals while sitting on the floor and in some instances the food is actually prepared there. The lighting and ventilation of many of the eating-rooms are far from satisfactory. The incoming air is frequently derived from a vitiated source, such as a common gully choked with garbage in varying degrees of decomposition and bordered by basket privies. Another and most frequent cause of bad ventilation is the cook-room fire, for whose smoke there is no exit other than the main door and windows.

In some of the eating-rooms, marble-topped tables are used which are capable of being properly cleansed. In other instances wooden tables covered with oil-cloth or linoleum are in use, whilst in others plain wooden tables coated with the grease of ages.

Cook-rooms.—The first essential of a cook-room is that it should be well-lighted and adequately ventilated. But in the majority of eating-houses, cook-rooms form part of the general eating-rooms, or are generally very badly lighted and ventilated. In a few instances, the *chowk* or interior open space of the house is used as a cook-room, an arrangement hardly contemplated at the time of building the house, as presumably the *chowk* is meant to act as a ventilating shaft for the upper floors. But the climax would appear to be reached when we find actually in the cook-room itself, or in close relation to it, basket privies. In one notable instance in the outlying districts of Bombay, the sweeper had to pass through the cook-room with his basket of night-soil to get at and clean the privy receptacles!

Apart from the general appearance of filth, due to waste vegetable and animal matter and grease lying on the floor and walls, and to the smoke-begrimed walls and ceilings, additional dirt is caused by the careless storing of the coke and charcoal used in cooking. Any odd corner, or even the table, is considered suitable for storage.

The tables on which the food is prepared are open to grave criticism, and it is a matter of rarity to come across one which has been subjected to a course of soap and water within recent times. In some instances no table is used, but merely a dirty plank. In fact, there is no doubt that the condition of the cook-rooms and the method of conducting the business of preparing food for human consumption are little short of scandalous, more specially in view of the facts that these houses were licensed. Such a title should be a guarantee of reasonable cleanliness but, one must confess, that as far as one has been able to determine, the only

guarantee conveyed by the license is the payment of a small fee for the privilege of dispensing food under grossly insanitary conditions.

Cleaning of dishes, etc.—Here also a great variety of practices obtains. In some houses a proper washing tray is used, consisting of a wooden table with raised edges, the whole being covered with zinc. Some of these tables discharge over or near properly trapped drain inlets, others are connected to storm-water drains, while many simply discharge on to the public road. In other houses the *nahani* is used for this purpose. The house gully is used by some for washing dishes, whilst others use a bucket. In certain restaurants the condition of the vessels would lead one to believe that any attempt even at cleansing vessels is unknown.

Removal of waste food and water and sweepings.—The almost total absence of any attempt towards an organised method of removal of waste products and sweepings is one of the conspicuous features of this trade. Practically all the eating-houses show evidence of neglect in the shape of unswept floors and tables strewn with waste food, of kitchens littered with scraps of meat or fish or waste vegetable matter. There is no proper receptacle kept for the purpose.

None of the premises contains any provision for the proper storage of milk, meat or any article of food. The milk is usually placed on the floor in an uncovered vessel, and a wisp of hay is packed into the mouth of the vessel, to prevent spilling. Meat is disposed of anywhere on the floor or table or hangs from the ceiling covered with flies.

The following conditions are being enforced in Bombay :—

(*a*) The licensee shall provide and maintain in good repair and use a metal sanitary dust-bin of approved pattern and provided with a lid. This dust-bin should be in daily use for the storage of waste food and sweepings of the floor, and the contents should be emptied daily into the nearest Municipal dust-cart.

(*b*) The licensee shall provide a table or tables for the eating-house proper. Such table or tables should be marble-topped or of wood covered with zinc on the upper surface or with such

other non-absorbent metal as may be approved by the Municipal Commissioner. Similarly, the licensee should provide one or more tables suitably covered for use in the kitchen.

(c) The licensee should provide and use a metal bin or metal-lined wooden bin for the storage of any coal, coke, charcoal or firewood used in the preparation of food. Such bin to be located in a situation approved of by the Assistant Health Officer. (This provision is insisted upon in bake-houses in England).

(d) The floor of every cook-room and eating-room should be paved or cemented.

(e) The walls of every cook-room and eating-room shall be lime-washed twice yearly, and the wood-work thereof shall be washed with hot water and soap at least once every twelve months.

(f) Every licensed eating-house should provide a receptacle of a standard pattern for the storage of water. This receptacle should be fixed in a definite position approved of by the Assistant Health Officer, who will be guided by the proximity or otherwise of drains, or drain inlets, gullies, etc.

(g) The Milk, meat and other articles of food should not be allowed to lie exposed but should be stored in proper meat-safes or cupboards.

(h) Every licensed eating-house should be provided with a proper washing place for cleansing dishes, cups, etc., used in the business. Such washing place should be properly drained and discharged over a half channel gully at a point at least 18 inches away from any drain inlet.

(i) Every licensed eating-house should be well lighted and well ventilated, and should at all times be kept scrupulously clean.

SWEETMEAT SHOPS.

Like eating-houses, a very large number of sweetmeat shops exist in the city of Bombay in highly objectionable and insanitary surroundings. The law has been amended to bring these places under proper control. They play an important part in the lives of many persons, as sweets form part of the daily food of many individuals in India.

The principal Indian sweets are *Halva, Ladoo, Julebee, Penda* and *Burfee.*

Halva is a viscous substance. It is made by soaking wheat for three days in a tub and then kneading the same. This process of kneading is generally carried on by means of naked feet, and the precaution of washing the feet before employing them for this purpose is sometimes not observed by careless workers. After this the whole is strained through cloth and washed, and the residue which is gluten is mixed with sugar and various spices and also flavoured with vanilla and other essences. The whole is then boiled in ghee, and afterwards laid on wooden slabs and cut in slices.

Ladoos.—These are either round or cone-shaped. They are made from gram flour, which is first mixed with water. This mixture is next sieved through an iron pan, the contents being dropped into a frying pan, full of sweet oil or ghee, and placed over a fire. The fried contents which appear like vermicelli are then mixed with sugar and spices and made into round or cone-shaped balls.

Julebee.—Wheat flour is mixed with water and allowed to stand for some hours. It is then stirred and mixed into a proper paste. This is then placed in a copper *lota* which is perforated with a single hole at the bottom. The *lota* is next held over a frying pan containing ghee and the contents are dropped into it through the hole in the form of circles. These are then dipped into a pan containing simple syrup and afterwards placed in copper or brass plates.

Penda and *Burfee* are purely milk preparations. The milk is first made into what is known as *mawa*. This *mawa* mostly comes from Surat and other places in Gujerat, and it frequently becomes stale by the time it arrives here.

The large majority of these sweetmeat shops are located on the ground floor of dwelling houses. The process of frying is carried on in open fire places, without any provision for the escape of smoke by means of chimneys. The smoke nuisance and the smell of frying ghee or oil are rendered still more objectionable by the trade being carried on in dark, ill-

ventilated rooms. There is little cleanliness observed in making of the sweets. Everything is done on the bare floor. There are no proper tables or even benches. The sweets are exposed in open trays for sale and flies are allowed to swarm over them in large numbers.

It is necessary for the safety of public health to control the conditions under which sweets are prepared at these places. Such places require to be licensed under conditions somewhat similar to those laid down in the case of eating-houses.

The conditions enforced in Bombay City are as follows :—

(1) The floor of every cook-room and sweetmeat shop shall be paved or cemented, and the cook-room shall be quite separate from the sweetmeat shop.

(2) The walls of every cook-room and sweetmeat shop shall be lime-washed twice in a year in the first week of April and October, and the woodwork thereof oil-painted every three years.

(3) The licensee shall provide a receptacle for the storage of water during non-supply hours. This receptacle shall be made of zinc, placed on a stand at least $1\frac{1}{4}$ feet above ground level, properly covered with a tight fitting lid and kept under lock and key. It shall be cleaned in such a manner and at such intervals as shall be determined by the Assistant Health Officer. The receptacle shall be fixed in a definite position approved of by the Assistant Health Officer of the Ward.

(4) All sweetmeats exposed for sale or stored on the premises and all sugar and other substances used in their preparation shall be kept in fly-proof bottles or vessels or protected against contamination by flies in some equally effectual manner.

(5) The licensee shall provide and maintain in good repair and use a metal sanitary dust-bin of approved pattern and provided with a lid. He shall use this dust-bin daily for the storage of waste food and sweepings of the floor, and empty the contents daily into the nearest Municipal dust-cart.

(6) The licensee shall provide one or more tables covered with zinc for use in the kitchen.

(7) The licensee shall provide and use a metal bin or metal lined wooden box for the storage of any coal, coke, charcoal or

firewood required for the preparation of food. Such bin or box shall be located in a situation approved of by the Assistant Health Officer of the Ward.

(8) The licensee shall provide a proper washing place for cleaning dishes, cups, &c., used in the business. Such washing place shall be properly drained and shall discharge over a half channel gully at a point at least 18 inches away from any drain inlet, and in the case of those sweetmeat shops located in a portion of the Island where a drainage system does not exist, the provision for disposal of waste water shall be such as will meet with the approval of the Assistant Health Officer of the Ward.

(9) The licensee shall keep his sweetmeat shop at all times in a cleanly state and he shall be liable to prosecution for failure to keep the premises in a proper state of cleanliness and for any neglect of reasonable precautions in respect of the storage of milk, sweetmeats or other articles for human consumption.

(10) All copper and brass cooking utensils shall be tinned at least every two months, or whenever the licensee is called upon to do so by the Assistant Health Officer of the Ward.

(11) The licensee shall not employ any person suffering from any contagious or infectious disease on the premises in any capacity.

(12) No portion of the sweetmeat shop shall be utilised for preparing sweetmeats or articles of a like nature on segris or chulas. Such articles shall be prepared in the regular cook-room.

(13) The licensee shall not put up, nor shall he allow to be put up any 'pan shop' at the entrance of the sweetmeat shop in such a manner as to obstruct the light and ventilation of the place. Such a 'pan shop' shall only be fixed in a definite position approved of by the Assistant Health Officer of the Ward.

(14) This license is valid only for the premises above specified, *i.e.*, for the number of rooms, shops, or space mentioned, and, if the licensee desires to carry on the said trade or any operation connected therewith in any additional room, shop or space in the said premises, he shall apply for a fresh license, which (if granted) will be subject to the payment of such additional or extra fee as may for the time being be properly chargeable in respect thereof.

(15) If the license-holder vacates or gives up possession of the said premises during the period of this license, he shall forthwith inform the Superintendent of Licenses of the same.

(16) The utmost cleanliness shall be observed in the various processes of preparing sweetmeats, and appliances shall be kept in a thoroughly clean and sanitary condition.

(17) In so far as the licensee sells milk or milk-products either separately or with any other food or beverage for consumption on or off the premises, he shall be deemed to be subject to the conditions prescribed for the sale of milk under license from the Municipal Commissioner, except that no additional fee shall be chargeable in respect of such sale of milk or milk-products.

(18) This license is not transferable either as regards the person to whom or the premises for which it is granted without the written permission of the Commissioner.

(19) The licensee shall cause this license to be affixed in some conspicuous part of the said premises.

(20) No impediment or encroachment should be made on the footpath in front of the sweetmeat shop by placing thereon chairs, benches, tables, soda water boxes or any other articles for the use of the shop-keeper or his customers.

(21) The licensee will, at all times during the continuance of this license, be responsible for the due fulfilment and observance of all the foregoing conditions, and in case of any infringement of, or neglect, or failure on the part of the licensee or of any other person employed or having any interest in the business to fulfil or observe, any of the said conditions the licensee shall be liable to prosecution and to suspension or revocation of this license.

AERATED WATER FACTORIES.

Along with bake-houses, ærated water factories have also to be licensed in Bombay City under section 394 (1) (*d*) (*i*). It has always been recognised that, if a supply of ærated waters prepared under wholesome conditions is to be looked for, such factories must be licensed or registered; and ever since they have thus been brought under proper sanitary control, many improvements have been effected in them.

Prior to the introduction of this legislation, it was found that very few ærated water factories in Bombay fulfilled even ordinary sanitary conditions. The factory premises, as a rule, were found to be unsuitable for the purpose as regards position, construction, light and ventilation. The water-supply was stored in receptacles which were open to contamination. The dirty bottles were washed in tubs containing

water which, though it may be clean to start with, speedily became very foul, and the whole business of the production and handling of the ærated waters was conducted without proper regard to cleanliness.

It is not only desirable but necessary in the public interest that certain structural and sanitary standards should be insisted upon in respect of premises used as ærated water factories, and the following requirements are now demanded in the case of all such factories.

(1) The building should possess the conditions of wholesomeness needed for dwellings in general and should further have arrangements fitting it for the special purpose of an ærated water factory.

(2) The rooms should be light, airy and well-ventilated, and the floor and walls should have a smooth and non-absorbent surface that can be easily cleaned.

(3) No drain or pipe directly communicating with a house drain or sewer should have an opening in the factory, and the factory should not have any windows or ventilation openings abutting on a sweeper's passage and should not be situated near a privy or other potential source of contamination.

(4) The water-supply of the factory should be from a service pipe connected to the Municipal main, or from a special covered cistern supplied with Municipal water, and so located as to admit of its being readily cleaned.

(5) The brushes used for scrubbing the interior of dirty bottles should themselves be cleaned and disinfected periodically, and the washing and the cleaning of the bottles should be carried out in running water or by means of a jet of water at high pressure.

(6) No person should be permitted to sleep in any part of the factory.

(7) The utmost cleanliness should be observed, in the various processes of manufacture, and the premises and appliances should be kept in a thoroughly clean and sanitary condition.

N.B.—The Bombay water-supply being chlorinated, is quite satisfactory for the manufacture of ærated waters provided the water is taken directly from the service-pipes. Where the water is stored on the premises in tanks or other receptacles or the source of water is not above suspicion bacteriologically, the water should be either boiled or filtered prior to its being used for such purposes.

BAKE-HOUSES.

As defined in the Public Health (London) Act of 1891, a "bake-house" means any place in which are baked bread,

biscuits, or confectionery, from the baking or selling of which a profit is derived. This definition is now adopted in the Bombay Municipal Act (Act 1 of 1916).

In large cities the sanitary control of bake-houses is a public necessity; it is more so in India, where bread and biscuit making is in many instances carried on in insanitary buildings and surroundings. Many of these establishments are such as are likely on occasions to become infected with the specific organisms of certain diseases, *e.g.*, Cholera, Enteric Fever and Tuberculosis, and such germs can easily be conveyed to the dough either by the air, by utensils, by the agency of flies, or by the hands of workmen. It is, of course, true that, from the consumers' point of view, the evils of insanitary bake-houses are to some extent counteracted by the process of baking, but carefully conducted bacteriological experiments have shown conclusively that baking does not necessarily destroy all the germs that may be contained in dough. Moreover, bread when taken from the oven is often allowed to lie about the bake-house for a considerable time, and there is then every chance of the crust becoming contaminated in one or more of the ways mentioned above. The insanitary bake-house is, therefore, a source of danger both to the bread-consumer and the bread-producer and, in the interest alike of the public and the workmen, certain structural and sanitary standards are obviously necessary in respect of premises used as bake-houses. These are briefly as follows:—

The building should possess the conditions of wholesomeness needed for dwellings in general, and should further have arrangements fitting it for the special purpose of a bake-house. Separate rooms should be provided for storing flour, for mixing and kneading the dough, for baking, and for storing the bread. The rooms should be light, airy and well ventilated and the floors and walls should have a smooth and non-absorbent surface that can be easily cleaned. The dough troughs and kneading tables should preferably be of glazed iron and movable, so as to admit of ready cleansing with water. If made of wood, the inner surface should be smooth and free from cracks, so as to prevent the lodgment of dough and putrescible material. The oven should be so arranged that no fumes can

escape into the room in which it opens, and the chimney should be of sufficient height. The bread when baked should be taken to a special room and kept in such a way as to protect it from contamination. A special lavatory should be provided for the work-people and it should not communicate directly with the bake-house, but should be quite detached. No drain or pipe directly communicating with a house drain or sewer should have an opening in the bake-house, and the bake-house should not have any windows or ventilation openings abutting on a sweeper's passage and should not be situated near a privy or other potential source of contamination. The water-supply of the bakery should be from a service pipe connected to the Municipal main, or from a special cistern so located as to admit of its being readily cleansed. No person should be permitted to sleep in any part of the bake-house, and no room on the same level as the bake-house and forming part of the same building should be used as a sleeping place, unless effectually separated from the bake-house, by a masonry partition extending from the floor to the ceiling. Lastly, the utmost cleanliness should be observed in the various processes of bread-making and the premises and appliances should be kept in a thoroughly clean and sanitary condition.

Under section 394 of the City of Bombay Municipal Act, no place can be used as a bake-house unless it is licensed, and the provisions mentioned above are being gradually enforced in the case of all such establishments where bread, biscuits, etc., are prepared on a large scale. But besides these regular bakeries, there is a number of small shops in *chawls* and dwelling houses at which biscuits, etc., are prepared in small quantities and sold on the spot. The rooms are partly used for human habitation, and in each of them there is an oven without any outlet for smoke. In such places the flour is kneaded in iron or tin trays, which are afterwards covered over with more or less dirty gunny bags to protect the unbaked biscuits from dust and flies.

Such small bakeries are somewhat akin to what are described as "retail bake-houses" in section 102 of Part V of the English Factory and Workshop Act, 1901. They cannot be expected to be brought all at once up to the European standard, and in their case the following requirements are demanded with a view to ensuring, as far as possible

the preparation of bread and biscuits under fairly wholesome and sanitary conditions :—

(a) Baking shall be done in a detached building and not inside any chawl or a dwelling house.

(b) All the walls and ceiling of such a bake-house should be lime-washed three times a year, in the months of January, May and September.

(c) The floor of the room should be paved with fine dressed stone-slabs, cement or tiles.

(d) The place should not be used as a sleeping room.

(e) No water-closets or privy should be within the bake-house or communicate directly with it. There should be separate cisterns or water-supply from the cisterns supplying water-closets. There should be no drain connected with a sewer inside the bake-house.

(f) The kneading of the flour should be done on clean, smooth wooden, zinc or marble tables.

(g) The flour should be stored in bags, which should not be placed on the ground but on a bench or table.

(h) The size of the oven should be such that it should occupy less than half the accommodation in the room ; and it should be provided with a suitable chimney.

BARBERS' SHOPS.

There are two classes of barbers' shops : (1) hair cutting and shaving saloons, and (2) *hamamkhanas* where baths (hot or cold) are provided.

A few saloons are satisfactory, but the great majority are not.

On inspection many of the saloons were found in a very dirty condition with tables covered with dirt and dust, shaving brushes and soap receptacles filthy, combs and hair brushes never cleaned, and visitors provided with dirty aprons and towels ; wash basins were in a filthy condition, and discharged into dirty buckets, not connected to the drain. No arrangements existed for proper wet sweeping or collection of the hair in covered receptacles.

The conditions necessary with regard to air space, ventilation, light, cleanliness of aprons, towels, etc.,

sterilization of razors, hair brushes, combs, etc., are enforced under the license.

As regards hamamkhanas, they are all kept by Mahomedans and are patronized by the same class of people. These hamamkhanas consist of two or three bathing cubicles with dirty and filthy walls and imperfect drainage arrangements. Where these bathing arrangements are so defective as to be dangerous to health or likely to create a nuisance, action is taken under section 394 (1) (*d*) (*ii*) of the Municipal Act.

Besides the saloons and hamamkhanas, there are itinerant barbers sitting in public streets or moving from house to house. Their towels and aprons are seldom washed and the same cloth is used for months together. It is necessary to bring this class of people under control as well; clean aprons, towels and brushes should be enforced.

Steps are taken to ensure that all the hamamkhanas throughout the City comply with the following standards :—

(*i*) The cubicles for bathing should be well paved with fine-dressed stone-slabs and properly connected to the drain.

(*ii*) Lime-washing of the premises should be done every 3 months.

(*iii*) A clean towel should be supplied for each bather.

(*iv*) The aprons used for hair cutting or shaving should be clean.

(*v*) A proper covered receptacle of a standard pattern should be provided for depositing hair, etc.

(*vi*) A cistern of the standard pattern approved by the Municipality with proper cover should be provided for water-supply to the bathers.

(*vii*) Implements used for hair cutting and shaving should be properly cleaned and disinfected after each use.

In the city of Paris the following rules are enforced :—

Cutting instruments should be washed in a 1 per cent. solution of carbonate of soda and wiped with a dry cloth. The combs and shaving brushes should be freed from accumulated grease each evening by washing them in ammoniated soap water. Metallic instruments should be passed rapidly through a flame before being used again. Brushes and combs should be kept in a hermetically sealed retainer containing

a saucer of 40 per cent. solution of formalin. Toilet powder should be applied only by means of a pad of sterilised cotton wool which should be destroyed at once. Barbers must be forbidden to sharpen their razors by stropping them on the palms of their hands. Regular customers should have their own individual apparatus kept for their use alone.

"Syphillis, Faruncaulosis, Tinea and perhaps Alopecia and other contagious diseases of the skin and scalp are not infrequently transmitted at the barbers' shops."

SEC. 394 OF THE CITY OF BOMBAY MUNICIPAL ACT.

394. (1) EXCEPT UNDER AND IN CONFORMITY WITH THE TERMS AND CONDITIONS OF A LICENSE GRANTED BY THE COMMISSIONER NO PERSON SHALL—

(*a*) keep in or upon any premises for any purpose whatever—

(*i*) any article specified in *Part* 1 *of Schedule M, viz.*,

Blood,	Gun-cotton.
Dynamite,	Blasting powder.
Fulminate of mercury.	Nitro-glycerine.

(*ii*) any article specified in *Part II of Schedule M*, in excess of the quantity therein prescribed as the maximum quantity of such article which may at any one time be kept in or upon the same premises without a license;

Article.	Maximum quantity which may be kept at any one time without a license.
Bidi leaves	4 cwts.
Celluloid	4 cwts.
Celluloid goods	4 cwts.
Cinematograph films	20 lbs.
Chemicals	4 gallons.
Cotton refuse and waste	4 cwts.
Cotton seed	4 bags not exceeding 4 cwts.
Ghee kept for sale	4 cwts.
Gunpowder	5 lbs.
Matches for lighting	1 gross boxes.
Methylated spirit	10 gallons.
Paper stored for sale as waste paper	4 cwts.
Petroleum, as defined in the Indian Petroleum Act, 1899	40 gallons.

Article.	Maximum quantity which may be kept at any one time without a license.
Dangerous petroleum as defined in the same Act	20 gallons.
Oil (other sorts)	15 gallons.
Saltpetre	¼ cwt.
Tar, pitch or dammer	½ cwt.
Turpentine	1 gallon.

(*b*) keep in or upon any premises for sale or for other than domestic use, any article specified in *Part III of Schedule M. viz.*—

Ashes,	Fireworks,	Hoofs,
Bamboos,	Firewood,	Horns,
Bones,	Fish (dried),	Jute,
Carbide of calcium,	Flax,	Offal,
Charcoal,	Grass,	Rags,
China grass,	Gunny bags,	Skins,
Coal,	Hair,	Straw,
Cocoanut fibre,	Hay,	Tallow,
Coke,	Hemp,	Timber,
Fat,	Hides (raw),	Wool (raw)
Fins,	Hides (dried),	

(*c*) keep or allow to be kept, in or upon any premises, horses, cattle or other four-footed animals—

(*i*) for sale,

(*ii*) for letting out on hire,

(*iii*) for any purpose for which any charge is made or any remuneration is received, or

(*iv*) for sale of any produce thereof ;

(*d*) carry on, or allow to be carried on, in or upon any premises—

(*i*) any of the trades or operations connected with trades specified in *Part IV of Schedule M. viz.*—

Baking,

Casting metals,

Dyeing cloth or yarn in indigo or other colours,

Keeping of eating houses,

Keeping of hair dressing saloons or barber's shops,

Tanning, pressing or packing hides or skins, whether raw or dried,

Manufacturing, packing, pressing, cleaning, cleansing or preparing by any process whatever any of the following articles :—

Ærated Waters.	Dammer.	Oilcloth.
Blasting Powder.	Dynamite.	Paper.
Bidis (indigenous cigarettes).	Fat.	Pitch.
	Flax.	Pottery.
Bones.	Fireworks.	Rags.
Bricks or tiles.	Gas.	Soap.
Candles.	Ghee.	Sugar.
Catgut.	Gunpowder.	Tallow.
Cotton or cotton refuse or cotton seed.	Lime.	Tar.
	Matches for lighting.	Vegetable oil.
Cowdung cakes.	Offal.	Wool.

(*ii*) any trade or operation which in the opinion of the Commissioner is dangerous to life, health or property, or likely to create a nuisance either from its nature, or by reason of the manner in which, or the conditions under which the same is, or is proposed to be carried on.

(2) A person shall be deemed to have known that a trade or operation is, in the opinion of the Commissioner dangerous or likely to create a nuisance within the meaning of paragraph (*ii*) of clause (*d*) of sub-section (1), after written notice to that effect, signed by the Commissioner, has been served on such person or affixed to the premises to which it relates.

(3) It shall be in the discretion of the Commissioner—

(*a*) to grant any license referred to in sub-section (1), subject to such restrictions or conditions (if any) as he shall think fit to prescribe or

(*b*) to withhold any such license.

(4) Every person, to whom a license is granted by the Commissioner under sub-section (3), shall keep such license in or upon the premises to which it relates.

(5) Nothing in this section shall be deemed to apply to mills for spinning or weaving cotton, wool, silk or jute or to any other large mill or factory which the Commissioner may from time to time with the approval of the Standing Committee specially exempt from the operation thereof.

CHAPTER XII.

VILLAGE SANITATION.

India is a conglomeration of villages. Unfortunately these villages are built without proper selection of site and the houses are generally closely aggregated together without the provision of sufficient open spaces between and around them and without proper roads and passages. Often there is no conservancy arrangement or efficient drainage and a good and copious supply of water is also not available. The ignorance of the people in the elementary principles of sanitation and their age-long insanitary habits conduce to make the villages still more insanitary. At times, mud, clay or gravel required for building the houses are obtained by making excavations in the neighbourhood of houses and the pits thus formed are used for depositing rubbish and become also breeding places for mosquitoes on account of collection of water.

Sanitation of villages in India is, at present, under the control of the District and Union Boards. The number of the latter however is not sufficiently large, and their revenue is also insufficient to enable them to undertake elaborate schemes for the improvement of the villages. In Bengal under the Bengal Village Self-Government Act a large number of village Union Boards are created, which work in union with the District Local Boards.

It is not possible for each village to have its own sanitary staff. It is therefore advisable for a group of villages to combine and provide an administrative organization comprising of a medical officer of health with a staff of sub-assistant surgeons, sanitary inspectors, nurses, vaccinators, muccadums, sweepers and other menial staff. The sub-assistant surgeons and vaccinators should be trained in sanitation and anti-epidemic work. They should be provided with an emergency outfit containing medicines for the treatment of common diseases like malaria, dysentery,

diarrhœa, etc., and disinfectants for treatment of suspected wells and for the disinfection of infected houses.

The medical staff and their subordinates should visit periodically all the villages within their respective areas and take steps to keep them clean and healthy. Arrangements should be made, for the prompt notification of outbreak of an infectious disease being sent to the nearest Police Station or Sanitary Inspector through special messengers. Wherever possible, stamped and addressed printed cards of different colours signifying different infectious diseases should be provided to the chowkidars or the village Head Men with instructions to post the proper kind of card on the occurrence of the first case of the disease.

Attention should be given to the Maternity and Child Welfare Work in the villages, and trained nurses should be engaged to guide and supervise the work of *dais*. The nurses should instruct the *dais* in the principles of aseptic midwifery and particularly to wash the eyes of the infants immediately after birth to lessen the incidence of blindness through Ophthalmia Neonatorum. As nearly 20 per cent. of the total blindness in India is attributed to this cause, the importance of training the *dais* in the prevention of this disease is evident. Facilities for the removal of women in difficult labour to the nearest Hospital should also be provided.

The commonest disease which prevails in villages is malaria and its prevention therefore is a matter of vital importance. The broad principles in the prophylaxis of this disease are the same in the case of cities, towns, and villages, and the student is referred to the chapter on Malaria and Mosquitoes in regard to them. But it is necessary to bear in mind, that the residents of villages are both poor and ignorant, and can ill-afford to have mosquito-proof houses, mosquito curtains, electric fans, and other appliances to protect themselves against the bites of mosquitoes. Main

reliance should therefore be placed on reducing the number of cases by free distribution and administration of quinine, plasmoquine, etc., and lessening the number of anophelines in and around the houses. It is necessary to draw attention again to what has been said above, regarding the evil habit of excavating earth from the neighbouring land for the construction of houses. Such excavations act as breeding places for mosquitoes, and serve to spread malaria. All such excavations and low lying places holding water should be filled in or drained. No inhabitant should be allowed to dig an excavation for building material less than a mile distant from the village boundary. The introduction of fish in wells would be a valuable anti-malarial measure.

Care should be taken to build the houses on a regular plan, with proper arrangements for light, ventilation, and open spaces. It is desirable to have cement floors in the houses, but if the floors are made of mud, as is usually the case, the mud should be dug up periodically and removed, and a layer of fresh mud should be put on. On no account should the floors be smeared with cowdung. Surface drains for the removal of rain water and slop water should be provided. Receptacles for storing the water-supply should not be left uncovered. A village Improvement Scheme may be started by designing proper streets, by preventing rebuilding of houses coming within the proposed set back lines of street, opening out congested areas, etc. This will not be difficult in villages as land is plenty and cheap.

The question of providing a pure water-supply in villages is important. Tube wells would be ideal for the purpose. But if funds do not permit of such wells being sunk, then ordinary tanks and wells should be constructed. It is necessary that these sources of water-supply should be protected from human and animal pollution. No cattle should be allowed to have access to them, and no bathing and

washing of clothes and utensils should be permitted near these places. A special bucket with a chain or rope should be provided for drawing the water and no other vessel or rope should be allowed to be used for the purpose. It would be an improvement to cover all open wells hermetically, pumps being provided to draw out the water. In the case of tanks it would be a good arrangement to fix a pipe in the centre and draw out water by that means.

The efficient conservancy of villages is a very important but somewhat difficult problem. Many villages have no latrines and the people have become habituated to the use of any open space, or banks of tanks, rivers or watercourses for purposes of nature. Owing to this pernicious habit, many water-borne diseases particularly cholera, typhoid, and dysentery, and intestinal parasites—notably hook-worm—are spread. House refuse, dung, slop water, etc., are indiscriminately thrown anywhere at the back of the houses, and allowed to accumulate in heaps. The result is that decomposition sets in, offensive odours are given off and flies breed in abundance. The remedy is to provide separate public latrines for males and females in the proportion of one seat for every 30 inhabitants and to insist on the people using them. The site of these latrines should be carefully chosen and should be easily accessible. The washings from the latrines should not contaminate any sources of water-supply. A sufficient number of sweepers should be engaged to clean these latrines—in a village of 500 inhabitants ten will be sufficient—and the night-soil should be conveyed some distance and disposed off either by incineration or by shallow trenching. If regular latrines cannot be constructed on the score of expense, then trench latrines properly screened off should be provided. For this purpose, a plot of land should be secured and divided into two portions. For 500 persons, a trench ten feet long, ten inches wide and twelve inches deep will suffice. A trench of this length can be screened off into

four seats. There should be a sweeper in attendance to cover the excreta with sufficient earth, which is piled up on the side. When the trench is filled up a similar trench should be dug further and so on till the whole land is used. Portion of the land not in use should be utilized for cultivation. House refuse, waste food and refuse from stables should also be carried away and burnt or it may be utilized for reclaiming low land and hollows. In the latter case the refuse should be covered up with two or three inches of earth on the top. If the Local and Union Boards have not got sufficient funds at their disposal, it is the duty of Government to aid them with grants. Any money spent for the improvement and sanitation of villages will always be well spent.

Lastly to ensure the success of sanitation in villages, it is of the utmost importance to educate the general public particularly in the elementary principles of hygiene and public health. General education of the masses should no longer be delayed. It behoves Government with the help and co-operation of the various health and social service leagues, to seriously take up this matter, and to set apart adequate funds for imparting free primary education to the masses. The rising generation of school children should be stimulated by rewards and special prizes to take an interest in sanitary studies, and primary hygiene should form part of their curriculum.

The best way of educating the illiterate public in villages is by means of lectures on sanitary matters delivered in simple homely language illustrated by lantern slides or Cinema shows. In order to indelibly impress these lessons on their minds, it is necessary to present both sides of a picture to them. For instance when speaking on healthy dwellings, they should have a clear grasp of the advantages of light, air, ventilation and cleanliness, and the disadvantages of living in overcrowded, ill-ventilated, dark, and filthy houses. It should be brought home to them

that in the former class of buildings people and particularly infants have a chance of longer lives and in the latter kind of houses people die quickly and in large numbers. The dangers of insanitary habits and pollution of water-supplies should be illustrated to them. Baby weeks and health exhibitions should also be frequently arranged.

In times of epidemics, instructions could be usefully imparted by means of leaflets and illustrated posters showing the dangers caused by flies in spreading diseases and the methods of suppressing them, the dangers from rats and the means to exterminate them and explaining simple measures to be taken when a case of small-pox or cholera occurs. It would also prove of very great use to give them simple and illustrated lectures on mosquito and malaria, and to teach them to recognize mosquito larvæ and how to destroy them by means of larvicides, such as kerosene oil. In this way each village could form a mosquito brigade of its own, and do a great deal of good in preventing the incidence of malaria.

CHAPTER XIII.

School Hygiene and Medical Inspection of Schools.

School Hygiene.

The question of school hygiene and its importance in regard to the welfare of the nation is coming into prominence, as its far-reaching influence is now more fully appreciated by the public. The latter now realise that attendance at school is necessary not only for the purpose of acquiring varying degrees of proficiency in the subjects usually embraced by school curricula but also, that concurrent with the absorption of such knowledge, the student should learn how to live : in fact, that he should acquire at least an elementary knowledge of personal and domestic hygiene and thus be enabled to appreciate his duties both to himself and family and also to his neighbours.

For two reasons at least, therefore, school premises should be constructed and maintained in a high degree of efficiency ; first, in order that the present and future health of the scholars may, in no way, be prejudiced ; and, secondly, that by the constant association of school life with order, cleanliness, good ventilation and general high standard of sanitation, the student may acquire both by practice and precept, a knowledge of the value of such surroundings and be the better able to reach and maintain a similar standard in his own home and vicinity. Practically, all the great cities of England are now spending large sums in educating a generation who had not the advantages now offered to the elementary-school boy, imparting to them the simple fact that cleanliness, free ventilation and light are the three principal agents in reducing sickness and death-rate.

The present generation of scholars are more fortunately situated in that they are acquiring that knowledge at a

period of life when the impression conveyed is more apt to take root and be remembered.

Apart altogether, however, from the educational value of good schools, such institutions not only promote the growth of healthy children, but very greatly diminish the spread of the zymotic diseases, so fatal to childhood, and of contagious diseases, such as ringworm, ophthalmia, scabies, etc. The influence on eye-sight is discussed further on under the heading "Light and Ventilation."

SITE AND SURROUNDINGS.

In choosing a site for a new school, one of the first considerations is that it should be so located as to afford easy means of access to the scholars attending it, and consequently be in a more or less central position. A noisy site is particularly undesirable not only on account of the difficulty in teaching, but also because of the natural lack of concentration of thought which it causes in young children. For this reason, for all new schools a quiet site should be selected, and if such cannot be obtained, the building should, if possible, be set back from the main street, preferably 60 feet at least.

In Indian towns many schools are situated in *chawls* or over shops or factories, in main thoroughfares, where throughout the day the noise of traffic, of itinerant vendors, or of trade processes serves to distract the already feeble attention of the child from the subject in hand. Others again are in close proximity to basket privies, wood depots, milch cattle stables and *dhobi-ghats*.

Of course, it must be recognised that the majority of buildings or parts thereof occupied as schools in India were not originally constructed for that purpose, but have been rented probably on account of convenience of situation and lack of the necessary funds for erecting more modern buildings. One cannot however but record the impression that those considerations have out-weighed the necessity for due

concern as to the physical welfare of the scholars, and that buildings have been occupied as schools which are totally unsuited to the purpose.

In regard to the construction of new schools, it may be taken that the site area should average $\frac{1}{4}$ acre for every 250 children. The modern tendency is to have a large central hall in which all the scholars can meet, and from this hall class rooms open. Where ground space is not of prime consideration, this central hall may be completely isolated from the class rooms but, where the site is limited, the hall should be separated from the class rooms by corridors open to natural ventilation. In either instance, the hall should be of such a size as to give a floor space of 4 square feet per scholar and be thoroughly well lighted and ventilated. Where ground is cheap and available, all the class rooms should be on the ground floor, but as in large cities this is practically impossible, upper storeys must be provided, though it is desirable that a public elementary school should not exceed two storeys in height.

In India, advantage should be taken of the climate, and "open air" classes encouraged as much as possible.

Cubic space per head.—In regard to the proper allowance of cubic space per head, much will depend on the climate. In colder climates a greater allowance of cubic space per head must be made, since the removal of the vitiated air cannot be carried out so often in any given time as in the warmer climates, unless the air be artificially heated prior to introduction into the school-room. The minimum cubic space laid down by the Educational Department in England is 100 cubic feet per head, while the London School Board require 130 cubic feet. Even this amount is on the small side, and Newsholme, Medical Adviser to the Local Government Board, considers that 150 cubic feet should be the minimum.

On examining 125 schools in Bombay, judged by the standard of the English Education Department, no less than

61.4 per cent. of the schools fell below the requirement, *viz.*, 100 cubic feet per head. Even if we make allowance for the difference in climate and adopt 90 cubic feet per head as a minimum, we still find a large number of schools with quite inadequate space. In some instances the cubic space per head fell as low as 20 cubic feet. In nine cases it was below 40 cubic feet, and in 15 instances the cubic space provided was between 40 and 50 cubic feet. The significance of these figures will be dealt with under ventilation.

Floor area per head.—Under the English Education requirements, 10 square feet per head must be provided, and for infants an average of not less than 9 square feet is accepted. Newsholme suggests as a minimum 15 square feet. Taking the requirements to be 10 square feet, we find that 61.8 per cent of the Bombay schools failed to reach this standard, and in one instance the amount provided was as low as 3.1 square feet, an amount totally incompatible with proper ventilation and personal comfort.

LIGHT AND VENTILATION.

Light.—The importance of good light cannot be overestimated, as any deficiency thereof is one of the chief causes of defective sight. The focal length of the normal eye for reading all ordinary type is about 12 to 14 inches, and for writing about 14 to 16 or 18 inches according to the size and character of the writing. If the light be defective, the scholar, not being able to read clearly at the proper distance, stoops to lessen the distance, with the result that the eyes converge and the muscular strain thus produced leads to a gradual elongation of the antero-posterior axis of the eyeball resulting in Myopia, *i.e.*, the image of the object seen forms in front of the retina (unless the object itself is very close to the eyes) and is very blurred and indistinct. Moreover, holding the head down over the book or paper tends to congestion of the vessels of the eye and general impairment of sight.

In any room the light should come directly from the sky, and no part of a room may be deemed sufficiently lighted from which a certain extent of the sky cannot be seen. In large cities, it is of course a matter of great difficulty sometimes to obtain this standard. In a building several storeys high forming part of a street, the opposite houses of which are of the same height, each room is divided into two regions of different degrees of illumination by a plane formed by a line drawn from the ridge of the roofs of the opposite buildings and the upper borders of the windows; below this plane the light is sufficient or, at any rate, is skylight, above it is insufficient, being diffused and reflected, not direct. In the upper rooms of the buildings, this plane strikes the opposite wall and in these rooms the whole of the occupied part of the room is in the light; but in the lower rooms this plane falls not on the wall but on the floor and a greater or less portion of the floor space will be in relative darkness and unfit for reading, writing or needlework. Now, the intensity of the light in a room depends on two factors: (1) *the angle of incidence*. Forster is of opinion that light should fall on the floor at an angle of not less than 25°, as the intensity diminishes inversely as the square of the area over which it is distributed, the increased obliquity of the incident rays reducing the intensity of the light; and (2) *the angle of aperture*, or the arc of sky visible at any given point in the room. This angle is greatest in the upper rooms and diminishes as we proceed downwards, until on the ground floor it may vanish altogether. It should never be less than 5° of an arc in any part of the room. The necessary amplitude of angular aperture is to be sought by increasing the height of the rooms, by carrying the window-heads nearly to the level of the ceiling, (the sills being 4 to 5 feet above the floor), by regulating the width of the rooms (this should on no account be greater than $2\frac{1}{2}$ times the height of the windowheads from the floor, which ratio gives an angle of 25° to the rays reaching the floor on the farther side of the room), and lastly, by

avoiding the proximity of buildings on the side from which light is derived.

Under modern conditions of life, specially in towns, one of the most important problems is how to obtain a sufficiency of light and air. The usual practice is to adjust the height of buildings to the width of the streets.

The London Building Act of 1894 prohibits the raising of buildings in streets higher than the width of the street.

As regards light and air in the rear, by the same Act an angle of $63\frac{1}{2}°$ is provided for.

The Bombay Municipal Act provides for an angle of 45° in regard to new houses. This angle predominates in many continental cities also.

This rule, however, applies to frontages only, and if all classrooms abutted on a frontage the light would perhaps be sufficient, but in many of the rooms in Indian schools, the light is derived not from a frontage but from a side-gully, or even in some instances *via* another room. In such a case the angle of aperture is *nil*, it being a physical impossibility to see the sky from any portion of the interior of the room.

In other cases the only light available comes from directly in front of the scholars. As a general rule, so long as light does not fall on the eyes either directly or by reflection, it can scarcely be too strong. The admission of direct sunshine into a school-room is undesirable, and for this reason a southerly aspect is to be deprecated unless there are windows on the north side also, in which case the former may be of ground or tinted glass. If the window space be ample and there be no obstructive buildings, a north light is agreeable; windows facing east and west are to be recommended, since in rooms so arranged there is no direct sunlight during school hours for the greater part of the year.

In schools the seats should be so arranged that the strongest light comes from the left hand side of the scholar ; when such light is impossible, the next best is right light. Windows full in the face of the scholar are most objectionable. This is a point to which but little attention seems to be paid in Indian schools. The window sills should be placed no more than 4 feet above the floor, and the window should reach nearly to the ceiling and be made to open direct into the external air. Although opposed by some, a strong argument in favour of cross-lighting from east and west is that the angles formed by the rays of the light with the floor from opposite sides are added and the intensity of the light is thereby doubled.

Ventilation.—The larger the air space, the less is the necessity for the frequent renewal of air and the less the chances of draught. Thus a space of 100 cubic feet must have its air changed 30 times in an hour if 3,000 cubic feet are to be given, while a space of 1,000 cubic feet need only have it changed three times. The warmth of the moving air greatly influences the sensations of the persons exposed to it. At the temperature of 60° Fahrenheit, a rate of $1\frac{1}{2}$ feet per second is not perceived ; 3 feet per second is perceptible to most and a rate of $3\frac{1}{2}$ is perceived by all, and any greater speed than this will give a sensation of draught. If the air be about 70°, a rather greater velocity is not perceived, while if it be still higher—80° to 90° Fahrenheit—the movement becomes again more perceptible. In the climate experienced in Bombay the change of air could be carried out at considerably greater speed than in a colder country, and consequently a smaller initial cubic space is required. Considerations of expense render it practically impossible to provide the theoretical amount necessary, *viz.*, 1,000 cubic feet of space per head. In Canadian schools an allowance of 250 cubic feet per scholar is insisted upon ; in Poor Law schools in England, 360 cubic feet. These amounts are based on the minimum requirements of a cold climate, and are probably

in excess of the minimum amount necessary under the conditions existing in Bombay, where 90 cubic feet per head might be accepted as a standard.

It should be remembered that the air supplied is frequently derived from tainted sources, through windows opening into common gullies in which are situated basket privies and in which decomposing food lies and into which all the household refuse is thrown resulting in choked drains. Apart from this, in many of the gullies, the air is practically stagnant owing to obstructive buildings.

It is obvious that for school purposes a building requires something more than mere compliance with Municipal by-laws, and that if proper light and ventilation are to be secured, a separate standard should be set up in regard to these two necessities. The area of the windows clear of the sash panes should be from one-fourth to one-sixth of the floor space, and wherever possible the rule should be observed that lines drawn from the bottom of the wall of the school building to the tops of the nearest adjacent buildings should not make greater angle than 30° with the horizon.

"Open air" classes are now commonly in use and should be valuable in India. The class rooms should be so constructed that at least three sides of it may be thrown completely open. Simplicity in construction with the provision of plenty of open space and fresh air should be the aim.

Open air classes should be particularly useful for certain classes of children *viz*: those suffering from malnutrition, rickets or anæmia; delicate children from the house where there is an open case of Phthisis; children with tuberculous glands in the neck; convalescents from debilitating diseases or after operations for glands in the neck, etc.; certain types of crippled children, nervous and highly strung children and those with myopia.

SANITARY CONVENIENCES.

The provision of proper sanitary conveniences is an important matter, as the absence of proper accommodation leads to the formation of undesirable habits. In many of the schools, the scholars, in the absence of a urinal, regularly use the *mori* as a urinal. As already suggested, attendance at school should involve more than the absorption of the elementary principles of Algebra, Euclid, etc., etc.; the scholar should also assimilate the knowledge of the benefits to be derived from fresh air, light and good sanitary conveniences It is but reasonable to suppose that, if he has been accustomed to plenty of air and light at school, and has experienced the advantages of the rapid removal of excreta from the premises by the water-carriage system over the old method of leaving such excreta in the immediate vicinity of the house and thereby poisoning what little air is available, he will become dissatisfied with the older insanitary methods under which the majority of the inhabitants live. Conversely, if in childhood and youth he has become accustomed to insanitary habits acquired at school, owing to absence of necessary accommodation, the incentive to elevate himself and improve his surroundings is absent. For this reason, and also on account of the prejudicial effect on his health while at school under such conditions, it is as essential as any subject in the curriculum that water-closets in sufficient number and urinals of modern pattern should exist in all schools; otherwise the student, who at that age is particularly receptive of impressions, will probably base his standard of living on the lines apparently recognised as sufficient and proper by the school managers. The use of the *mori* as a urinal should be absolutely prohibited. In all mixed schools, separate closet accommodation should be provided for the two sexes—a requirement which is not observed in certain of the existing schools.

The following table shows the number of closets required :—

Number.		Seats. Girls.	Boys.
under	30 children	2	1
,,	50 ,,	3	2
,,	70 ,,	4	2
,,	100 ,,	5	3
,,	150 ,,	6	3
,,	200 ,,	8	4
,,	300 ,,	12	5
,,	500 ,,	20	8

For boys, urinals at the rate of 4 per cent. are necessary in addition.

CLASS ROOMS.

The walls of the room should be tiled or painted so as to permit of regular washing ; the colour should be a pale and subdued one, *e.g.*, greenish grey. The junction of the wall with the floor and ceiling should be rounded, so also the junction of one wall with another, in order to facilitate cleansing.

The floor should be of concrete or tiles, which should be thoroughly washed every day. In many schools the floors are of koba and are consequently cold.

All staircases should be at least 5 feet wide with a door at the bottom opening outwards.

Desks.—The bulk of the schools in Indian cities do not contain any desks at all. The provision of desks involves a large expenditure if they are of the proper pattern ; and it is most important that they should be of the correct position and pattern, as this has an intimate bearing on the growth of less vigorous children, faulty position leading to rounded shoulders, imperfectly developed chests and spinal curvature.

Desks should be arranged parallel to one another at right angles to the windows and, wherever possible, should be placed in the space intermediate between two windows. The desks should be from 16 to 18 inches broad and have a slope of about 15° for writing and 45° for reading.

The seats must be of such a height as to allow the scholars' feet to rest on the floor and be broad enough to support the greater part of the thigh. They must have a back placed at such a height as to fit the hollow of the back below the shoulder blades and support the body in a vertical position. When used in writing, the edge of the desk must overhang the edge of the seat by an inch or two, in order that the scholar shall not need to stoop forward. Either the desk or seat must be movable at pleasure, so that, although the desk usually overhangs the seat, the scholar may be able at any time to stand upright in his place.

Cloak rooms.—In India possibly this accommodation may be thought unnecessary, but a room should be provided wherein to place umbrellas and cloaks used during the monsoon period. Cloak rooms should be provided and should be capacious, well-ventilated and fitted with numbered pegs at intervals of at least 12 inches.

Water-supply.—In the majority of schools in India, water appears to be stored in earthenware chatties placed in a variety of situations, most usually the *mori*, drinking cups being used in common by the scholars. This custom may be a means of spreading infective throat troubles unless the most careful attention is paid to the cleanliness of the cups. Moreover, means should be adopted to obviate the necessity of dipping the cup into the chatty in order to obtain water. The best way is to store water in a copper vessel with a tight-fitting cover and a tap attached below through which the water may be drawn out. In a school with many scholars, such a custom will obviate any contamination of the water which is otherwise inevitable.

Meals.—The practice of the scholars partaking of the midday meal in the same room as they have been working all the morning should be abandoned, as the midday interval is a suitable occasion on which to open all the windows and doors of the class-rooms so as to obtain as thorough a renewal of the air in the room as possible.

SELECTION OF BUILDING FOR SCHOOL.

It is not possible that the educational needs of a city can be met by new buildings in every instance and consequently old buildings not specially designed as schools must continue to be used, and it is in respect of this type that a measure of reform is necessary.

Before a building is rented or leased for the purposes of a school, reference should be made to the Sanitary Engineer and the Health Officer for a certificate that the premises are suited for the purpose. In granting this certificate, or otherwise, consideration should be paid to the lighting, ventilation and provision of sanitary conveniences, and in respect of ventilation the certificate should state maximum number of scholars permissible in each room on the lines of the Common Lodging Houses Act of England. In estimating this number, the present standard of the Bombay Schools Committee may be followed, *viz.*, 10 square feet and 90 cubic feet per head, where free and adequate ventilation is available. Intelligent co-operation on the part of the teachers is also necessary, as there are many instances of rooms in the same building in which the number of scholars in each room is in more or less inverse ratio to the respective cubic capacity of the rooms. This is merely want of supervision and co-operation; while there would be still room for this the system of certifying the maximum capacity of each room would serve to prevent the existing gross over-crowding.

In regard to lighting, great attention should be paid not only to the intensity of the light, but also to its source in relation to the students. The certifying officer should

express an opinion as to the sufficiency thereof and also state the most suitable method of arranging the scholars, with a view to obtaining left light if possible and of avoiding what is so frequently seen, front light. In any room it is quite as easy to conduct a class on proper lines as on wrong ones, given initiative and knowledge on the part of the teacher. Where these are non-existent, the certifying officer can supply the necessary information.

In regard to sanitary conveniences, it is of the first importance that no building should be certified until adequate provision of water-closet and urinals has been made. In mixed schools these must be separate. In connection with the use of water-closets, &c., much more severe discipline is necessary and no false and hypothetical religious scruples should be held to condone misuse of such conveniences. Until the youth of a city is made not only to understand the proper method of use, but also to put such into practice, we cannot hope to derive the full measure of benefit that should follow the introduction of Western methods of removal of excreta.

Medical Inspection of School Children.

Medical inspection at school concerns the State, the public health and the individual.

The State requires a physical census of the children for the discovery of unrecognised defects, partly with a view to the improvement of the national physique and partly with a view to the preparation of all children for school life. It is also a national duty to arrange for the classification of children according to their mental capacities, and to adopt the educational system to the requirements of the several groups of children, in order to diminish the present economic wastage of misdirected educational efforts.

It is the duty of the local authorities to protect the individual against communicable diseases in school, to supervise school buildings and to secure healthy surroundings for the school child.

Owing to ignorance, neglect, or apathy on the part of parents, it becomes a requirement of the merest humanity to bring medical aid and special educational methods within the reach of the individual child.

These aims and ideas can only be attained by the introduction of a system of routine inspection of the children by medical men interested not only in public health but also in education.

School hygiene may be regarded as the latest development of education in its more comprehensive aspects; it is the initial step in a great scheme of progress, a scheme which involves the improvement of the existing conditions of mental, moral and physical development of the children. The scheme also aims at the prevention of disease in childhood, and at raising the standard of national physique. Its final goal is the development of a science of education itself. These aims are definite and practical and may be summarized under the following heads:—

(1) Routine medical inspection;

(2) Physiology and psychology of ordinary educational methods, etc.;

(3) Special educational methods for abnormal children of the many different types—the mentally and physically defective, the dull and backward, the blind, deaf and the debilitated, etc.;

(4) Scientific supervision of school methods, *i.e.*, of nursery schools, school furniture, buildings, baths, ventilation, lighting, etc.;

(5) Physical education, including supervision of manual training, gymnastic exercises, organized games, dancing, etc.;

(6) Teaching of hygiene to teachers and others; and, lastly,

(7) Prevention of infectious diseases and attention to the sanitary condition of the premises.

The duties of a medical inspector are—

1. To examine every child, about the time of its admission to an infant school, as to cleanliness and as to its obvious physical defects. The first examination should be conducted in the presence of parents and guardians.

2. To examine in detail every child about the time of its transference to the upper school, that is about seven years of age, and to decide what special educational training (if any) is suitable to the child.

3. To visit and inspect all classes once or twice a year, both as regards the general health and physique of the children and also as regards the conditions under which they are working, namely, the ventilation, lighting, etc., on the one hand and the amount and kind of work, over-pressure, fatigue, physical exercise, manual training, etc., on the other hand.

4. To make special visits to the boys' and girls' departments once a year for the purpose of examining all children suffering from defective vision and to report upon eye-disease generally. The teachers should test the vision of all children once a year, but the doctor's examination can scarcely be undertaken at the time of his visits for other work, except in very small schools.

5. To supervise the work of nurses with regard to ringworm, vermin and skin affections, and to visit each school once a week or once a fortnight for the general examination of special children selected by the teacher or nurse.

6. To advise the Schools Committee upon various points of hygiene bearing upon educational matters, and to give definite instructions about the care of delicate and defective children.

7. To give lectures to teachers and others upon School Hygiene and elementary Physiology.

8. To deal with the question of medical certificates of absence given by other practitioners. The duty may be combined with the weekly visit to the schools.

9. To investigate (if necessary) in conjunction with the Health Officer all epidemics and outbreaks of infectious disease in the school, and also to take measures to prevent not only the spread of the disease but also the unnecessary closure of the school.

In 1907, an Act was passed in England and came into force in January, 1908, providing for the medical examination of school-children.

Section 80 of the Education Act of 1921 makes it the duty of the local education authority for elementary education to make adequate and suitable arrangements for attending to the health and physical condition of children in elementary schools and for their medical inspection immediately before, or at the time of, or as soon as possible after, their admission to the school and on such other occasions as the Ministry of Health may direct. (2) Authorities for higher education must provide for medical inspection and may also provide for treatment, and (3) may on request attend to pupils of schools whether or not aided by them. (4) Authorities

are to encourage voluntary agencies engaged in the work referred to in this section and shall consider how far they can avail themselves of the services of private practitioners.

In a memorandum on the Medical Inspection of Children in Elementary Schools (Circular 576), the Board of Education state that "the Board desire to emphasize that this new legislation aims not merely at a physical or anthropometric survey, or at a record of defects disclosed by medical inspection, but at the physical improvement, and as a natural corollary, the mental and moral improvement of coming generations."

The Board add that "while it is not expected that by establishing the necessary administration on the broad basis of public health all difficulties will be avoided, the Board are convinced that this is the only practicable method and that which is most likely to promote economy, harmony and efficiency." The Board express the opinion that "in county areas the County Council, which is the local education authority, should instruct their county medical officer, who will be responsible for the smooth and effectual administration, to supervise the work, its actual execution being deputed wholly or partly to suitable medical colleagues or assistants (men or women), who either will be appointed specially for the purpose under him or will be local Medical Officers of Health and to whom groups of schools may be allocated. . . That is to say, generally speaking, the work of inspection should be supervised by the Medical Officer of Health of the authority which appoints the Education Committee; and when the work is obviously more, than he can undertake unaided, it should be entrusted to one or more medical officers working under his supervision." The memorandum further discusses the character and degree of medical inspection, and states that the Board have decided that not less than three inspections during the school-life of the child will be necessary to secure the results desired. The first inspection should take place at the time of, or as

soon as possible after, admission to school; the second at or about the third year (say the seventh year of age); and the third at or about the sixth year of school-life (say, the tenth year of age).

The Board also discuss the subject of amelioration and physical improvement, for which a scheme has to be submitted by the local education authority for the sanction of the Board of Education, and in conclusion urge "the progressive unification of the Medical Services."

The minimum requirements of the Board of Education are (1) a medical inspection of every child not less than three times during its school-life; (2) the registration of the facts thus recorded (the register to be kept at the schools); and (3) the submission to the local education authority and the Board of Education of a detailed annual report of the work and its results.

At the same time, both the Board of Education and the Local Government Board expressly stated their view that this work was part of the general work of public health and their desire that it "should be carried out in intimate conjunction with the public health authorities and under the direct supervision of the Medical Officer of Health;" and in Circular 576 they further affirm the principle that "as far as is practicable the School Medical Service should be unified with the Public Health Service." The advantages of such unification of the Public Health Services had already been recognized by the Inter-Departmental Committee on Medical Inspection and the Feeding of School Children.

Organization in England.—Turning to the organisation in England, we find that the respective functions of the Board of Education and the local education authorities are clearly defined by the Act. The duties thrown upon the Board consist in advising local education authorities as to the manner in which they should carry out the provisions of the Act and, in supervising the work they are

called upon to undertake, in giving such directions as may be necessary regarding the frequency and method of inspection in particular areas, and in considering and sanctioning such arrangements for attending to the health and physical condition of the children as may be submitted to them by individual authorities. The Board will also collate the records and reports made by the authorities and will present an annual report to Parliament.

The duty of carrying out the annual inspection has necessarily been entrusted by Parliament to the local education authorities and not to the Board. Each authority must therefore in due course appoint such medical officers or additional medical assistance as may be required for the purpose.

In view of the varied influences which affect, directly or indirectly, the health of the children of the nation, it is manifestly of the highest importance that the administration of this Act should rest upon a broad basis of public health, and should not only secure for local education authorities as much freedom as is consistent with adequate uniformity in the presentation of results for comparative purposes, but should also use to the utmost extent the existing machinery of medical and sanitary administration, developing and supplementing it as required, rather than supplanting it by bringing into existence new agencies, partially redundant and possibly competing.

The Board view the entire subject of school hygiene, not as a speciality or as a group of specialities existing by and of themselves, but as an integral factor in the health of the nation. The application of this principle requires that the work of medical inspection should be carried out in intimate conjunction with the public health authorities and under the direct supervision of the Medical Officer of Health. The Local Government Board specifically require every Medical Officer of Health to report officially upon matters relating

to the sanitary condition of all schools, including the "action taken (by the Sanitary Authority) in relation to the health of the scholars and for preventing the spread of infectious disease. . . . . "

School hygiene, the Board of Education observe, cannot be divorced from home hygiene, and this in turn is intimately bound up with the hygienic conditions of the community. Efficiency and economy require, therefore, an organic relationship between the daily work of the school authority and of the authority responsible for the administration of the wider branches of public health, including the supervision of water and milk supplies, food, housing and sanitation, inquiries into matters affecting infant mortality (including ante-natal influences, home-visiting by men and women inspectors, sanitary and bacteriological investigations, the provision of hospital accommodation, disinfection, the cleansing of verminous persons, the notification of the prevalence or otherwise of diseases such as Phthisis, affecting the adult population, and the consideration of social factors, such as the occupation of the parents, or the health-habits and physical conditions of the family, all of which have a bearing direct or indirect, upon the children's health.

Generally speaking, the work of inspection is supervised by the Medical Officer of Health or the authority which appoints the Education Committee; and when the work is obviously more than he can undertake unaided, it is entrusted to one or more medical officers working under his supervision. In some districts it is convenient for such officers to be local Medical Officers of Health holding office within the county; in others, they are registered medical practitioners specially appointed for this purpose. Provided that the principle of co-operation of the medical services is secured in practice, and that the requisite personal and professional qualifications for the new work are present the functions of the School Medical Officer may be exercised by a Medical Officer of Health, a Poor Law Medical

Officer, a private practitioner, or as occasion requires, a skilled specialist. There are many cases in which women are likely to be specially suitable. In making such appointments, preference is given to medical men and women who (1) have had adequate training in State Medicine or hold a Diploma in Public Health, (2) have had some definite experience of school hygiene, and (3) have enjoyed special opportunities for the study of diseases in children.

Subsidiary agencies.—It must be distinctly understood that the work of medical inspection cannot be properly accomplished by medical men without assistance. The teacher, the school nurse (where such exists) and the parents or guardians of the child must heartily co-operate with the school Medical Officer. In whatever way the system be organized, its success will depend, immediately and ultimately upon the cordial sympathy and assistance of the teachers.

The increased work undertaken by the State for the individual will mean that the parents have not to do less for themselves and their children, but more. It is in the home, in fact, that both the seed and fruit of public health are to be found. All-round co-operation between school Medical Officer, teacher, nurse, health visitor and parent will prove both effective and economical.

CHARACTER AND DEGREE OF MEDICAL INSPECTION.

From what has been said it will be clear that the fundamental principle of the English Act is the medical examination and supervision not only of children known, or suspected, to be weakly or ailing, but of all children in the elementary schools, with a view to adapting and modifying, the system of education to the needs and capacities of the child, securing the early detection of unsuspected defects, checking incipient maladies at their onset, and furnishing the facts which will guide education authorities in relation to physical and mental development during school-life.

The directions given in the circular issued by the Board of Education as to the degree and frequency of inspection refer only to the minimum medical inspection, the effectiveness of which is to be one of the elements to be considered in determining the efficiency of each school as a grant-aided school. They are not intended to exclude other medical work, which should be undertaken by local education authorities, according to their abilities and opportunities. For example, the periodical re-testing of the eye sight of every child; an annual measurement of height and weight; the more frequent examination of particular children, especially of those suspected to be suffering from deficient nutrition or found to be defective at former inspections; careful anthropometric surveys or special inspection at various ages of school-life; and similar investigations of a special nature, undertaken in particular districts, come within the category of additional medical work, wholly desirable where practicable, and calculated to advance school hygiene. Such work, however useful, has to be looked upon as subsidiary to the main purpose of the Act.

Regulations.—The Board of Education in England have decided under section 80 of the Education Act, 1921, that not less than three inspections during the school-life of the child will be necessary to secure the results desired. The first inspection should take place at the time of, or as soon as possible after, admission to school; the second at or about the third year (say, the seventh year of age); and the third at or about the sixth year of school-life (say, the tenth year of age). A further inspection immediately before the departure of the child into working life would be desirable where practicable, and in some areas it may be best for this to take the place of the third inspection. Certain adjustments will be necessary in working out any standard in practice, as it will at once be evident that without such adjustment the first year would be unduly burdened with the inspection of the

children newly admitted and of all the children already in school.

Each authority has been directed to make provision when the Act has been sufficiently long in operation to be in normal working, for the inspection in each year of (a) the children newly admitted; (b) the children in the school who in that year had matured for their second inspection; (c) those who had matured for their third inspection; and where practicable; (d) those about to leave school. But in the first year it may prove impracticable to attempt more than the inspection of the children newly admitted and those leaving school; and in the second year it is considered sufficient if those newly admitted and those leaving are inspected, with the addition of children who have matured for their second inspection (which is perhaps the occasion of all others requiring the most thorough examination). Such adjustment tends to equalize the burden over successive years. The precise way in which the children are grouped in the school for medical inspection may vary according to the internal organization and circumstances of each school. It may be most convenient, for instance, to carry out the inspection on an age-basis rather than on a basis of period of school-life.

There are some further regulations—

(a) The inspection should be conducted in school hours and on school premises, and in such a way as to interfere as little as may be with school work. The examination of each child need not, as a rule, occupy more than a few minutes.

(b) The convenience of the teaching staff and the circumstances of each school must receive consideration, and in these matters and in the actual examination the Medical Officer will no doubt exercise sympathy and tact, giving due thought to the personal susceptibilities of those concerned.

(c) The facts revealed by inspection must be entered in a register kept at the school, (somewhat in the following form), the confidential nature of many of the entries being carefully respected. A copy of the entries should be transmitted with the child to any other school to which he or she may go.

Name :— School :—
Address :— Date of Birth :—
Illness previous to admission :—
Family history :—
Date :—
Standard :—
Without Shoes { Height :— Weight :—
Vision { Teacher — Doctor :—
Hearing { Teacher :— Doctor :—
Age at examination :—years, months.
Remarks :—
Date :—
Cleanliness :—
Clothing :—
Physical stature :—
Nutrition :—
Teeth :—
Throat and nose :—
Eyes :—
Ears :—
Speech and mental capacity :—
Remarks :—

INITIALS OF EXAMINER.

(*d*) Every school Medical Officer should make an annual report to the local education authority on the schools and children under his superintendence, which should be printed for facility of reference and in order that a supply of copies may be available for distribution among the members of the authority and other persons interested. The authority should send two copies of the report to the Board of Education as soon as possible after the end of the year under review.

(*e*) In order to secure effective basis for comparison of the work done in different parts of the country, one uniform year must be taken the year to be adopted being in all cases the calendar year, in order to correspond with the annual period fixed for the closely related report of the Medical Officer of Health.

(*f*) The report should be concerned chiefly with the conditions and circumstances affecting the health of the children in the elementary schools of the district.

(*g*) It should also contain statistical records of the number of children examined and of those re-examined or under medical supervision: the nature and results of the examination; the number of visits paid to classes; the number and character of the diseased conditions found at certain age-periods; particulars as to blind, deaf, defective and epileptic children; the medical advise given both as to the prevention of conditions inimical to health and remedy of diseased conditions that may be discovered; action taken, and so forth.

(*h*) In addition to such records it will be well, as far as practicable, to make systematic comparisons of the individual and collective measurements and characteristics of the children in each school with standard and local records, both as a means of determining the condition of health of particular children or classes, for guidance in future action, and as part of the anthropometric survey to which this Act should contribute in due time. This part of the work, however, must be kept in a secondary position while so much remains to be done in the elementary essential of school hygiene. It is to those essentials and the manner and degree in which they have been dealt with in his district, that each school Medical Officer should devote the major portion of his report.

Medical inspection of schools forms an integral factor in every modern system of education, and its expediency may be assumed from its successful administration in other countries.

Fundamentally, the State control of health inspection depends upon the fact that a large proportion of children attending State schools, are suffering from preventible and remediable diseases. It matters not for the moment to what extent the home is responsible nor how far the diseases are aggravated by school life. It is sufficient that the defects are unrecognized either by teachers or parents, who alone are in contact with the children.

Hence it is clearly a national duty to discover a system by which these preventible and remediable defects may be brought to light. It is unessential to the State whether the health inspection of its children takes place in the school, at the home or elsewhere, so long as a physical census is taken and all defects are investigated, but seeing that the

children are collected together during nine or ten years of their life in State schools for the purpose of education, it becomes a matter of convenience to delegate the nation's responsibility to the Education Department.

The *a priori* argument for the State control of a system of health inspection rests upon the fact—which cannot be denied—that there are present in the schools (town and country alike) children suffering from preventible and remediable diseases, of which both the teachers and parents are ignorant; besides others, suffering from diseases the serious nature and consequences of which no one but a medical man can recognise. The assertion scarcely needs the support of figures and statistics, but it is stated in the report of the Chief Medical Officer to the Board of Education, England, that more than 80 per cent. of the children are suffering from defective teeth, that 50 per cent. are affected with vermin or other parasitic conditions, 20 per cent. with defective vision and that 10 per cent. are retarded in their educational progress by physical defects, such as anæmia, general debility and deafness resulting from adenoid growths or discharging ears; in addition to these, in India, Malaria, enlarged spleen, intestinal diseases and worms, &c., will have to be considered.

As long as there are in the schools such children as those that have been described, so long the necessity for systematic health inspection is obvious from all points of view. In other words, medical inspection in the elementary schools is necessary, because the parents are ignorant. It is only a means to an end, and at present the end is the education of the people. Indeed it has been argued that it devolves upon the State at the present day to make good its defective training and education of the parents, during the last twenty or thirty years, by directing a system of health inspection towards the education of parents and children alike. For, if all parents had been taught the elements of healthy living and were able to recognize the presence and to realize the

importance of physical disabilities and defects in their children, systematic health inspection would theoretically be out of the question. Medical advisers to local education authorities would still be necessary.

But, as matters stand to-day, the interference of the State is essentially justified by the large amount of preventible and remediable defects among school-children. These defects are unrecognised either by teachers or parents, and can only be discovered by systematic medical inspection.

THE PROBLEM IN INDIA.

If the work of school medical inspection is of such value in England, it must be doubly valuable in India as, in addition to the minor ailments and physical defects which would come under notice and about which advice would be given to the parents regarding prevention and treatment, the control of infectious diseases and Tuberculosis and Malaria would be of immense benefit to the public health conditions of the country.

In Bombay there are 522 Primary Schools—both Municipal and aided—with about 74.000 pupils, and 56 such unaided schools with more than 3,926 pupils.

The population of children of school-going age is about 1,25,000, thus leaving about 47,000 children who do not attend school and who could not be at present brought into this scheme.

Thus 80,000 pupils are a very considerable proportion of the City's school-age population, and the need for a measure that will help to improve the health and physical condition of such a large number of our future citizens requires no emphasis, whether from the standpoint of public health or education. The need is all the greater as the mass of poor and ignorant population is so much larger and the elementary laws of health and hygiene are so ill-understood.

It is not suggested that the Schools Committees of the various Municipalities rush at once into a large staff of Medical Inspectors, as is done in England, but gradually adopt a scheme which would lay the foundation for future development.

In England the cost of school medical inspection is about 1 shilling per head of the averge school attendance. A beginning could be made in Indian towns at a cost of about annas six per head, if the work be done by the Health Department.

In England the Medical Officer of Health in all the large towns and counties is now also School Medical Inspector on increased salary and under him is the local Health Officer as Assistant Medical Inspector.

There will be a large amount of inspection as well as clerical labour and correspondence, and this cannot be done by the staff of the Health Department without considerable assistance, as it is generally over-burdened. But the question is so intimately connected with the public health that it cannot be divorced from it and in order that a start should be made, the Health Department of each Municipality should be asked to undertake the work on suitable terms. The alternative would be to appoint a separate medical officer who has had experience in school hygiene, and two or more full-time medical officers with suitable office and staff with several lady district visitors and nurses, making a separate department altogether; but this would be more expensive.

How to Take a Physical Census of School Children in India.

The following is an example of an experimental examination of the physical condition of the children attending four schools in Bombay.

The examination was conducted by four District Registrars—qualified medical men—under the supervision of an Assistant to the Health Officer.

The work was carried out with a view of estimating the expenditure required to carry out a complete physical census of the children attending Municipal Schools in Bombay.

The work was performed at the time stated to be most convenient to the Head Masters.

Of the 313 children examined.	Per cent.
Vision was defective in	21.40
Hearing	14.05
Teeth were	43.76
Throat and nose were defective in	41.53
Glandular enlargement existed in	6.70
Head and body uncleanly in	37.69
Clothing uncleanly in	47.92

These figures indicate that it is desirable to obtain information on a larger scale.

From the experience gained in this experiment on a small scale, it has been ascertained that on an average 10 minutes are required for the examination of each child, exclusive of time taken in recording the weight and height and in entering the name, age and address of each child; this latter information was supplied by the Head Masters; the weight and height were not recorded owing to there being no apparatus for the purpose.

In conducting a census on a large scale, these points would be attended to by the nurse.

Assuming that there are roughly 16,000 children to be examined, one man working continuously for 8 hours per day would take about 333 days to finish all the school children.

On the average there are 78 holidays, and in addition 52 Sundays, which are also recognised as school holidays

and some of which, however, will probably coincide with the various public holidays. Allowing, say, that 10 such Sundays, will occur in a year, we have 365—less 78 and less 42=245 working days. So that one man working hard for 8 hours per day could not finish the census in one year.

It is almost impossible that one man could stand the physical strain of 8 hours' continuous labour per day for such a period; and moreover, the estimate above given makes no allowance for time taken in going from one school to another, and does provide for absolutely consecutive periods of 10 minutes for each child for 8 hours per day. This, as already stated, is practically impossible.

To do the work properly and to avoid scamping, three men working whole-time would be necessary; that is the number required if the Schools Committee elect to employ whole-time men. These men would probably finish the work in about 5 months.

As the work in the first instance would be of a temporary nature and as it is very desirable to obtain reliable information, it is suggested that the pay offered for such work should be fixed at Rs. 175 per month.

On the whole it is recommended that the employment of three whole-time men would probably be the more satisfactory arrangement.

From the list of schools supplied by the Committee, it appears that there are 112 Municipal Girls' Schools.

It is distinctly desirable that the examination of the height, weight, head and skin of the children in these schools should be conducted by a nurse and, further, that a nurse should be present when the children are being examined for hearing, eye-sight, etc.

When not engaged in this work, the nurses must record height and weight of the children in the boys' schools. Three nurses are necessary for the purpose at a remuneration of Rs. 75 per mensem.

A considerable amount of clerical labour is involved in the scheme. The forms are filled in by the District Registrars themselves, but a summary is necessary.

From the point of view of expenditure there is practically no difference in expense, whether the work be carried out by the existing staff of the District Offices or by special whole-time men.

If possible, a small room or a separate *verandah* should be placed at the disposal of the medical man during the actual period of examination, in order that the work of the school should suffer a minimum of interference. Otherwise the whole work of the class may be interrupted during the period of examination, due to a lack of intelligent co-operation between the staff and the medical man which should soon disappear. It is quite unnecessary to suspend the lesson. All that is required is that the master permit 1 or 2 children to leave the class, in turn, be examined and return immediately to work.

To establish such an orderly system will be one of the nurses' most important duties, as it is desirable not to interfere with the teaching carried on in the least practicable degree. The use of a separate room would, of course, largely conduce to this object.

MEDICAL INSPECTION OF SCHOOLS IN BOMBAY.

Medical inspection of school children was started by the Schools Committee of the Bombay Municipality in the year 1914 and at first it consisted merely of examination of school children by the Medical Inspector and noting percentages of different defects among them. The defects which in the opinion of the Inspector, required treatment, were communicated to the parent or guardian of the child and he was asked if he would have the child treated privately or would like it to be attended to free at a Municipal Dispensary. In the majority of cases the defects remained untreated, the

parents either promising to get the children treated privately and never doing it or obtaining an authority for free treatment at a Municipal Dispensary and never attending the dispensary.

The Schools Committee gradually realised that medical inspection of this nature was useless and that if it was to be of any value it must be followed by proper and systematic treatment of the defects noted.

A School Clinic at the King Edward Memorial Hospital at Parel was therefore established in 1930, where children are being given proper and regular treatment under the guidance of the School Authorities.

The School Medical Inspection staff at present consists of—

One Medical Inspector,

One Assistant Medical Inspector,

One Lady Medical Inspector (for Girls' Schools),

One Nurse to assist the Lady Inspector, and

One Part-time Dentist.

The number of children attending primary schools in Bombay is about 74,000. Out of these, about 17,000 are from the Aided Institutions not under the control of the Schools Committee and are not subject to Municipal medical inspection. The remaining *i.e.*, about 57,000 are to be examined by the School Medical staff. Each Medical Inspector examines nearly 5,000 children per year and on this basis it takes nearly four years for the staff to finish one round and examine all children once. The total period of attendance at these schools in Bombay is four years so that during its primary school life, a child would be examined only once. This is not a satisfactory arrangement and an increase in the staff is essential if the work is to be carried out satisfactorily. The routine method of examination is as follows :—

Three days previous to the proposed visit of the Medical Inspector, the Head-master of the school is sent

an intimation by him that the school would be inspected on the particular day and a form is sent in which the Head-master or the class teacher is requested to fill up the details about each scholar such as the name, residence, caste, guardian's name, age, date of birth, height, weight, etc. The Medical Inspector then visits the school and examines the children class by class. The examination is conducted in the class-room itself and the details of the examination of each scholar are filled in a form. When a defect is noted which requires treatment, the parent or guardian is informed and with his consent the child is taken to the School Clinic for treatment. If at the School Clinic, it is found that to remedy the defect a surgical operation would be necessary, the parent's consent is obtained for the same in writing and he is asked to present himself with the child at the School Clinic. The School Authorities take all responsibilities for the operation as well as the subsequent treatment and have made arrangements with the King Edward Memorial Hospital Authorities for the purpose. The children who require other treatments are taken to the School Clinic from the schools directly in a motor bus under the direct control and supervision of a school teacher. The grouping of children according to the particular kind of treatment required and other matters connected with treatment at the School Clinic are arranged by a Medical Organiser appointed by the School Authorities. The children receive treatment in separate departments according to their diseases, *viz.*, Medical, Surgical, Dental, Ophthalmological, Ear, Nose- Throat and Skin Departments.

CHAPTER XIV.

Habits and Customs in relation to Health.

The habits and customs of a people form a very large factor in relation to health and disease in every country; and although it may be considered utopian to think that this subject can be successfully dealt with in a work on sanitation in India, we venture to assert that, on careful investigation, some practical suggestions can be made which, if not acted on immediately, will form a basis for the sanitarian to follow in the future. We base our opinion on the hypothesis that the progress of sanitation among the masses, though slow must, by the pressure of public opinion and the ever-increasing demands of education for improved surroundings, make its influence further dominant; and the object of this chapter is not so much to blame the habits and customs as to point out in what direction habits and customs, which will take much time and enormous patience to alter, do affect the health of a people.

Mention has been made how ignorant and passively resistant the ordinary Indian is to any measures, for the control of the spread of infectious diseases, which affect his customs and habits; and we propose to briefly explain how some features of Indian life may affect the general health of a community. Take for example, the pollution of drinking water, whether it be in a well, tank, temple, or mosque; the washing and bathing, the casting of offerings and the absence of any attempt to keep the supply clean. Observe the preparation of food and sweets and the exposure for sale of articles of food; the method of collecting and distributing milk, and the conditions of domestic life; for example, it is not only the poorer class who sit on the ground and eat their food with their hand out of the same dish, but also among some of the better classes this custom prevails. In the streets can be seen curry and *dhal* vendors ladling out food with the hand to any passing purchaser; about schools

it is common for groups of children to purchase sweets or food from itinerant vendors, who mix the foodstuff with their hand and serve it on a piece of paper or leaf smirched by flies, crows and dust. In the houses of most classes, the father or mother feeds their children, who are seated on the ground, out of the same vessel, the father first taking his food, the mother afterwards. Again the proximity of animals: goats, fowls, cows, bullocks, dogs, etc., living in the same room as the tenants of houses; the amount of rubbish in houses and the facilities rats, fleas, bugs, lice, mosquitoes and flies have for propagating disease. No one with any experience of the homes of Indians in large cities, small towns or villages can fail to notice these features of common life; and to allow them to continue when they can be gradually removed is a policy which no conscientious sanitary official could accept, although he may realise the enormous task before him.

In mofussil towns and villages immediate relief cannot be hoped for, but as the inhabitants gradually emigrate to large cities they become surrounded with different conditions, and it is then they learn the value of improved sanitary surroundings and systematic supervision. It will, however, take many years of strenuous endeavour on the part of the sanitary official, before he can get the people to realise the necessity for observing any sanitary precautions; this is nothing new in the sanitary history of the world and it becomes the duty of the Municipality to constantly impress on the people, by precept and example, the necessity for the observance of the laws and by-laws relating to health. The municipalities should boldly take up this question and, while recognising the superstitious and religious objections, cope with the ignorance of the people, and gradually create a desire on their part for healthier surroundings.

With the knowledge we obtain of the ways of thought of many of the illiterate, it is easy to see how difficult it is for the people to understand why rats, flies, fleas or

mosquitoes should be avoided. Constant explanation is necessary by the sanitary official of the reason why measures are taken. Every infant at school should be taught the lesson of the hygiene of every-day life. All schoolmasters should have to undergo training as to the conditions affecting health.

If the religion of certain castes makes it incumbent on them to spare every living thing, it does not prevent them from taking steps to remedy filthy surroundings, and learning from their own people, who have acquired a wider insight and knowledge of the world, how to ameliorate their position. Examples of this can be seen daily in the enormous number of educated Indians taking up special branches of work in commerce, medicine, law, etc., and settling down in India after having acquired experience abroad, who are rapidly dispelling many of the prejudices, habits and customs which have long proved a stumbling block to progress. The development of technical education has enabled delicate engineering, surgical and mechanical operation to be carried out by Hindu, Parsi and Mahomedan artisans. The Indian labourer in town has overcome his prejudice against the innovation of foreign appliances and the *mali* can be seen wheeling a wheel-barrow which formerly he proposed to carry on his head.

The enormous amount of sanitary work carried out by the municipalities of larger towns and the interest the members of the corporations take in sanitary measures mean progress.

In previous chapters, practical suggestions have been attempted and it is only necessary to briefly summarise a few points, which should be borne in mind by the sanitary official when dealing with the habits and customs of the people.

Water-supply.—Objection is taken by some to drink any water unless it comes from a well. The water, however liable to be polluted by its surroundings, is preferred by some

to tap water, and a pump cannot be fixed as it is opposed to religious prejudice. The water from the well is drawn up in all sorts of vessels which may have been used for other purposes. The washing of clothes and utensils and animals and bodies of persons takes place at the well or tank side and the well or tank is a breeding place for mosquitoes.

The danger of this proceeding is palpable to any one. The water is examined and proved unfit for use. But to persuade the people that this is so is another matter. The remedy lies in constant supervision, the provision of a wholesome supply, the protection of the wells, and the adoption of a pump instead of open domestic vessels. Such pumps are now in common use in Bombay.

Milk.—To the majority of the people, pure milk is unknown. The method of keeping cows and buffaloes, the manner of milking and cleaning the vessels and the accepted adulteration with unwholesome water are of such common occurrence as to be a habit.

Proper regulations of dairies and cow-sheds, constant inspection and control, and the provision of Municipal milk depots will gradually induce the people to realise the advantages of cleanliness.

Food-supply.—The preparation of foodstuffs and their exposure for sale are still of the most primitive order even in large cities. By-laws for the control of eating-houses, bake-houses, soda-water factories, sweetmeat shops, milk-shops which insist on proper sanitary measures and protection from flies will gradually bring about great improvement.

Over-crowding : ventilation.—The high rents in large cities and the paucity of suitable accommodation for the poorer classes tend to overcrowding, which brings in its train sickness and distress. The custom of joint-family life is to a certain extent responsible for much of this, while the *purdah* system increases the evil.

The laws and by-laws governing this subject are very difficult of application. The inspection of houses liable to be overcrowded if done in the day-time reveals little and there is no power to inspect at night. It can, however, always be ascertained whether a room is overcrowded or not, and if the law is set in motion, temporary improvement can be made, but a remedy can only be found in extending action on the part of the municipality or local authority by providing suitable accommodation for the poorer classes; reference to which has been made in the chapter on the housing of the people.

Mention may be made of the manner of disposal of the dead, nursing of the sick, isolation of the infected; early marriages and a high birth-rate, prostitution, sexual indulgence and venereal disease, drugs, intemperance, infant mortality, child-birth, many of which are dealt with under different headings and should be taken up by the sanitary authorities.

India is peopled by diverse races, each having its own social and religious customs and domestic habits which have been ingrained in the course of ages, so as to be innate and form a part of the integral whole, whether of the individual or the community to which he belongs.

The customs and habits of the indigenous people, whether in villages, provincial towns or presidency cities, vary according to the community. Wherever members of particular communities go, they faithfully adhere to and persevere in the customs and habits which from infancy they have acquired and practised. For purposes of description, it would perhaps be most instructive to discuss the usages, habits, and customs as they obtain among communities of different religions in a presidency city. The better classes will be treated first, and a special reference will be made to the customs and habits of the labouring and depressed classes.

The City of Bombay is a large commercial emporium and seaport of the East; it has the fame of being cosmopolitan. Khurds and Tartars from Central Asia travelled to it in earlier days and settled therein; also Mahomedans, chiefly of the Sunni sect, from the plateaux beyond the north-eastern frontier, and Persians of the Mahomedan Shia sect; Arabs from the Arabian Peninsula and the enterprising commercial community, the Parsis; Hindus of all denominations and castes from the various parts of the vast continent of India have settled here. Hindus comprise nearly three-fourths of its population and Mahomedans more than one-eight. The great aim of the Mahomedan religion in making proselytes in India was to destroy in those converted the castes of Hindus with their customs, usages and habits. In this they only partially succeeded. In Gujerat, large districts were converted both by Shias and Sunnis. The two great Mahomedan commercial communities in Bombay, who hailed from Gujerat, are the Halais and Kutchi Memons and Khojas, the former being Sunnis and the latter Shias.

MOHAMEDANS.

Localities were selected by individual affluent and influential Memons and Khojas, whereto flocked others of the same classes converting the localities thus occupied, now known as *mohollas*. In families the Mohamedan religion was to a considerable extent successful in destroying caste prejudices, while retaining (to determine disputes and suits) the Hindu law and introducing a new element known as the *purdah* system, as also new religious rites with respect to customs at marriages, births and deaths. The Arabs, who were the first to arrive in Bombay from the West with commerce, intermarried amongst the aborigines of the Island, the progeny being *Natiahs*, from whom descended the great Kokni Mohamedan community now chiefly occupying the central portion of the City. These, on account of their constant intercourse with Hindus, acquired many of their customs

and habits. In justice to this community, it must be acknowledged that many acquired Western education and refinement and became highly respected leaders of society; while Memons, being essentially commercial until only recently, stuck to trade. The Khojas, the greater number of whom belong to the Shia sect, being a very pushing and enterprising community, availed themselves rapidly of Western education, adopting Western habits. The *purdah* system amongst them now exists only in name.

It is Khojas alone who, during the early years of Plague, availed themselves of isolation hospitals and inoculation. The Borahs, another Shia community, coming mostly from Surat and Ahmedabad districts, also availed themselves to a degree of isolation hospitals, but not of inoculation. With these exceptions the Moslem communities have a repugnance to removing their sick, in case of Plague or other infectious diseases, to isolation hospitals, etc. Even when different isolation hospitals were provided in different *mohollas* for them, the people were averse to the same, and to some hospitals not even a single case was brought.

The Kokni and Deccani Mohamedans show a great dislike to hospitals, and never to any appreciable extent took advantage of the same; perhaps this may be due to the want of religious or social heads in these communities, the result being that they suffered severely owing to concealment of cases. With the exception of the Khoja community none of the Mohamedan communities have sought the immunity conferred by inoculation. How far inoculation has been successful in this community is proved by their relative immunity from Plague. Mohamedans as a community prefer their sick to be treated at home and nursed by their relatives, whether suffering from infectious diseases or otherwise. Although the services of qualified medical men are to a great extent now availed of, yet their instructions with

reference to infective material are passively resisted and ignored. This is so not only with reference to Plague, but also other highly infectious diseases such as Cholera, Small-pox, Measles, etc. The infective material is not destroyed, but disposed of anywhere, preferably into house gullies. No particular care is taken by the relatives who nurse the sick, in spite of the instructions of the medical attendant, and no attempt at personal disinfection made; hence, infection is apt to be rapidly conveyed to the attendants or other members of the house. The backward classes in these communities have recourse largely to *hakims* for treatment. The *hakims* have scarcely any knowledge of personal or public hygiene. Vaccination, being compulsory, is availed of amongst Mohamedans and the children are vaccinated, some of them at a very late date. Revaccination amongst them is practically unknown. When Small-pox cases occur in houses, they are carefully concealed, lest the Health authorities coming to know of them should remove them to the isolation hospital, as required under section 424 of the City of Bombay Municipal Act. The concealment is however never complete, as there is a superstitious belief among all the uneducated classes that *neem* (*Melia Azadirachta*) leaves hung up at the entrance of the room prevent the spread of the disease and have also a beneficial effect on the patient. The custom of hanging the twigs of *Melia Azadirachta* (*neem*) is very ancient. May this have not been intended as a danger signal for intending visitors?

The patient is generally placed on a mat on the floor, rarely on a low cot. The bed clothes are aired in the passages or over the small fireplace. On the 7th day, after the first appearance of the eruption, a bath of a decoction of *neem* leaves is given to the patient in the *nahani* or *mori* of the room, and the body is dried with a soft towel or cloth. With those who can afford it, this towel or cloth finds its way in the house gully, whilst among the poor the same is used after being merely washed.

During convalescence the scabs are allowed to fall about the house or room, and are swept to the passage or on to stairs once or twice a day. One can therefore imagine how rapidly Small-pox spreads amongst the unprotected in a *chawl* and in its immediate neighbourhood.

The customs and usages relating to their dead will be briefly described here.

The Borahs (Shia sect) in this respect have taken the lead; their dead are immediately removed to the *musjid* mortuary; where the ablutions and other rites are performed before the final disposal of the remains in the cemetery. All the rest of the Mohamedan communities wash their dead in their houses on low wooden flats or benches provided by the *musjid* authorities. No disinfection is allowed in rooms or houses occupied by the deceased for three days and until the end of the *ziarath* ceremony, the family, in the meanwhile, occupying the room where the deceased suffered, receiving mourners and guests therein. The backward classes amongst the Mohamedans have a great aversion to disinfection and other sanitary measures. They have a special dislike to sterilizers, and in most cases conceal the infected bedding and mattresses, which are either washed at home or sold, or otherwise disposed of. They believe in *kismat, i.e.*, fate.

The advent of Mohamedans in India amongst Hindus has been iconoclastic in tendency and has led to domestic usages in direct opposition to those of Hindus. Beef was made the staple food of the classes. Mohamedans, as a rule, indulge in mixed diet, while a large proportion of Hindus are vegetarians. The Mohamedan prefers to eat his food in eating houses or restaurants. The hygienic condition of these eating-houses is very bad. The floors are filthy; the tables and benches are unclean and practically no store-room exists for prepared food stuffs, these being placed underneath a stair or even in close proximity to a privy, water-

closet, a *mori* or washing place. Generally, food stuffs are kept in open trays without any cover to protect them from flies; if covered, it is generally with a dirty sodden cloth. Contamination, therefore, of these food stuffs is frequent and almost certain. These eating-houses are now licensed by the Municipality, in consultation with the Police. On festive and mourning occasions, dinners are prepared in large cauldrons, which perhaps for years have not been tinned, and served to friends and members of respective *jamats*. During dinners, one drinking utensil is common to a party, and dinners are served in streets or on ground bare or partially covered by mats, if sufficient accommodation cannot be found in houses. A few of the *jamats* have opened large houses called *baughs* for such occasions, but only the rich avail themselves of these. It is nothing unusual to notice milk and curds exposed in open utensils next to a privy, or on the sill of a window opening into a neighbouring house gully. Further, water for drinking purposes is perhaps never boiled and is stored in *ghurras* (mud pots) and copper pots, on the wall of the *mori* or *nahani*. One possible cause of the introduction of Cholera into Bombay is water brought by pilgrims from the sacred wells of Mecca, in bottles and tin cans. This water is frequently mixed with a larger quantity of Bombay water and doled out to friends and relatives.

In the houses of the backward classes, a *mori* is provided in every room, and serves as a urinal at all times and as a water-closet during illness. The backward classes on account of certain habits they have, and which they will not correct, misuse water-closets and hence prefer basket privies.

HINDUS.

Three-fourths of the population of India are Hindus. These are divided into several castes, chief of which are Brahmins, Kshatrias, Vaishias and Shudras. The last include all low-castes. The Brahmins are the priestly caste,

highly educated, ministering the religious rites of all the other castes. They are essentially vegetarians. The only animal food they partake of is milk. For descriptive purposes, all of these castes may be divided into two great divisions :— (1) those strictly vegetarians, who include milk in their diet and (2) those who partake of mixed diet. To the former belong the Brahmins, Bhattias, Jains, Shravak Banias, Marwadi and Lohanas, and to the latter, Shenvis, Prabhus, Panchkalsis and Marathas in general and the last, all the Shudras, who eat indiscriminately everything and partake of meal-leavings from all houses.

Until recently, the floors of houses occupied by Hindus of all denominations in this City were of earth, as even now in almost all mofussil houses. A recent Municipal regulation enforces that floors should be of koba, cement and chunam. The practice that obtains in mud-floor houses is to smear them with a mixture of cowdung, red earth and water which give not an unpleasant coating to the floor. Disinfection with chemical solutions, even the most potent, is for obvious reasons impossible ; the disinfectant fluid, unless used in enormous quantities, becoming inert. Such house-floors are very suitable places for the breeding of fleas. Cowdung may also be the medium or vehicle of diseases, such as Diarrhoea, Typhoid, Tubercle, etc. Animals suffering from specific diseases may also by this means convey diseases to man. Mud floors being soft allow rats to make rat-warrens underneath. Experience has taught that such floors should not be allowed and hence the Municipal regulation of koba floors. The practice of smearing floors has nearly become a confirmed habit in the people inasmuch as even to this day smearing is resorted to in kitchen and dining rooms on koba floors. It is to be noted that almost all Hindus, except among the higher and the higher middle classes, squat and lie on floors.

The higher classes are cleanly in their habits and it is pleasant to see how tidy and clean they keep their lodgings. But they do not trouble themselves about their surroundings ;

and even the lady of the house could be seen throwing out the sweepings, etc., from her own house in the house gully or on the roof or wall of the adjoining house, there to decompose and prove a source of nuisance to her own family. The open spaces round about a chawl, being a common property, are frequently misused by the children of the locality and serve for the purpose of receiving all sorts of rubbish from the occupied rooms.

The middle classes occupy single or double rooms according to their means in tenement houses, the *mori* in these rooms being used for all purposes.

Some castes of Hindus generally hold their caste dinners in *mahajan wadis*, specially built for this purpose. The dinners may be festive or mourning. Ladies are served first; gentlemen after; no plates are used; the meals are doled out on plantain leaves or, when these are not available, on circular *patravalies* made of dried leaves of the *Butea fromdosa.* Each guest has to provide himself or herself with a small *lota* for drinking water. The water used is well water or water stored in huge underground tanks. This water is liable to contamination with droppings of birds from above, or with the washing of hands and feet of the guests before they partake of the meals.

In the first years of Plague, the people protested violently against disinfection, but experience has proved to them the benefits of disinfection and now without demur they accept it or call for it. The destruction of animal life is repugnant to all Hindus, especially to vegetarian classes *i. e.*, Brahmins, Banias, Jains Bhatias, etc. Even vegetarians are enjoined by certain rules to partake only vegetables of a particular kind; thus it is strictly forbidden for Jains to eat any succulent roots, tubers or bulbs, potatoes, carrots and onions, while they are permitted to eat the vegetable stalks and leaves emanating from such tubers. The meal hours are always during sunlight. The object of not eating a meal after sunset is to

prevent ingestion at lamp-light of animalcules by mishap. Amongst the Bhatias there is a large number of individuals who are known as *murjadis*. *Murjadi* implies the attainment of a higher degree of religious merit after a pilgrimage to the shrine of Gocul. The *murjadis* will not use shoe-leather, or drink water from a service pipe. They are strictly enjoined to drink water from wells alone. A vast number of houses is occupied by such *murjadis* and, although warned not to drink water from wells declared by the Municipal Analyst as not fit for potable purposes, they will indulge in the same and ignore such warnings. There is no alternative therefore for the Municipality but to fill up such wells or pump them dry. During illness, they seek the advice of medical men, but will take nothing but powders.

It is a common belief that illness is the consequence of the displeasure of some deity, to propitiate whom steps are therefore taken. These may consist in asking a priest to worship in a temple with certain formalities, or may take a form distinctly dangerous to health: for instance, the worship which is performed when a person, especially among the lower classes, is suffering from Small-pox.

During the epidemics of Plague, the Shravak Banias, Bhatias, and Lohanas suffered severely. These people are all traders and mostly reside in Mandvi on upper floors, the ground floor being used as a store-room, or godown for rice, sugar and other wares of this kind. These store-rooms are of necessity infested by rats. The religious repugnance of the inhabitants to kill or even to remove the rats after they have sickened and died leads to the infection of houses, and residents of upper floors succumb to the poison. Among Hindu traders, the Jains and Shravaks suffer most. According to the returns, the proportion of deaths amongst them is remarkable, being double that among low-caste Hindus. Isolation hospitals in the earlier years of Plague were held in repugnance by these

people as by Mahomedans, and for same or similar reasons. But when private isolation hospitals were established, they took advantage of them very largely. Inoculation is objected to by them on the ground of the animal origin of the vaccine; on the other hand, though the vaccination vaccine is also of animal origin, they readily take it as it comes from a cow or calf, which is held in special reverence and veneration. In cases of infectious diseases, no special opposition is met with in regard to disinfection. Speaking of infectious diseases, Small-pox is venerated in houses as the visitation of a deity, people refusing to remove such cases to hospitals voluntarily. This is a fruitful source of infection to the unprotected and the neighbourhood. The relations of the patient, his friends and neighbours visit him on such occasions and are exposed to the infection and may themselves convey the disease to others. On the 11th day of the disease, when the pustules are scabbing, a patient is conveyed, generally in a public conveyance, to certain temples where the goddess "Shitala Devi" is propitiated by offerings, &c. This is another source of public infection. The Health Department authorities are constantly obliged to proceed against such offenders and get them fined by magistrates.

The females amongst Hindus during menstrual and lying-in periods are considered as defiles and untouchable. They are set apart in rooms and have no social intercourse, and during lying-in period are attended by ignorant *dais* or midwives. For this reason municipalities should provide trained midwives, whose duties should be to be helpful during the lying-in period, to advise mothers on infant feeding and to act as Sanitary Inspectresses generally.

When a high-class Hindu is on the point of death he is laid on a country blanket (*ghongdy,*) white or black as may be available at the time in the house, and a basil leaf and some holy water are put in his mouth. If a son is present,

he takes the dying head on his lap and, when all is over, the women sit round the body weeping and wailing; the nearest female relatives affectionately caress the dead face with their hands and often use the free end of the *sarees* to wipe the face. The body is next washed near the steps of the house, dressed in white *dhoti* and transferred to the bier and conveyed to the *ghat* for cremation. The blanket and bed-cloth are given to the poor.

The lower castes after the ablution anoint the dead body with turmeric and butter, while females with the free end of their *sarees* whisk the face, frequently wiping it. The body is dressed up gorgeously and conveyed on the bier for cremation. All infants and persons dying from Small-pox are usually buried. The whole of the above description applies, *mutatis mutandis*, in a lesser degree to the mixed diet classes. Because of *purdahnashin* system, notification of disease is accepted with great reluctance, if at all. Notification of infectious diseases has been more successful during the last decade than in previous years, but the fear and abhorrence of official interference still prevail, with the result that there is much concealment of cases. The wealthier classes of Hindus avail themselves of qualified medical treatment, the poorer classes being unable to do so; municipalities should establish free dispensaries for medical relief. In Bombay these are largely availed of by the poorer Hindus and Mahomedans. All sorts of ailments, infectious or otherwise, are treated, the Medical Officer, if necessary, attending the patients at their homes. The establishment of these dispensaries will lead to the better registration of births and deaths and sickness.

PARSIS.

Parsis, who in the earlier Plague years were averse to notification of Plague cases and the use of isolation hospitals, have since the establishment of Parsi Fever Hospital by their *Punchayat* behaved in a most exemplary manner in these respects. Disinfection of rooms, where deaths

occur, is readily consented to after the funeral ceremonies are over. Their funeral rites are interesting. When a person dies, after due ablutions, the body is conveyed to the ground-floor and handed over to two or four of *khandias or* corpse-bearers. The corpse is then dressed by them and placed apart in a ground-floor room on the stone slabs, where no one is allowed to approach or touch the body. In the interval before the removal of the body to the Tower of Silence, which invariably takes place in the morning between 8 and 9 and in the afternoon between 3 and 4, a priest (*andheroo*) continuously chants prayers before the body. Before the corpse's final removal from the house, a ceremony called the *gaihe sarna* is performed, which consists in the chanting of special prayers by a couple of priests who stand on the doorway. These prayers are made in two parts. During the first part, the body continues to lie on the slab. This over, a dog is brought in and the dead body is exposed to its gaze a few minutes. The corpse is then transferred to a bier by *nassesalas*, special corpse-bearers, who alone can consign the body to the Tower of Silence,—the *khandias* carrying the body from the house to the Tower. The second part of the ceremony is now gone through and completed, when the mourners all approach the room, where the corpse is, to have a last look at it. Further ceremonies are performed for a period of four days on the ground-floor, the place in the meanwhile being inaccessible to disinfection. The leaders of the Parsi community, being well-educated, have set an example to other communities with reference to inoculation; but the middle and poor classes of Parsis do not take to inoculation to any considerable degree.

INDIAN CHRISTIANS.

The Indian Christians of Bombay consist of mixed descendants of old Portuguese settlers of Bombay, Goanese Catholics immigrating into Bombay for trade and other

means of livelihood, and the converts from the poorer classes of Hindus and Mahomedans by Protestant and Catholic Missions. The community, as a whole, is not wealthy and, although in the beginning was reluctant to isolation hospitals, has shown courage and devotion in sending their sick to public hospitals. All arrangements for segregation and disinfection are submitted to without opposition or murmur. They also very largely avail themselves of free dispensaries and of inoculation. Most of the poorer classes hailing from the northern districts of Goa are unprotected against Small-pox and, whenever Small-pox breaks out, this community suffers severely.

THE LABOURING CLASSES.

The most important of the labouring classes who come to Bombay are the Maratha Hindus. In the districts they are chiefly cultivators and agriculturists. They come from the Konkan and Deccan—also called *ghattis* from the *ghauts*. The latter are tall, sturdy and of strong physique, the former smaller and weaker. They supply domestic servants, coolies, mill-hands, weight carriers in grain godowns, in the docks and the Cotton Green, and some are engaged in petty business, as fruiterers, vegetable dealers, grocers, cart drivers and masons. They live in *chawls* generally in single tenement-rooms, but those who can afford, in double tenement-rooms. Many Marathas do not bring their wives or families with them. They then club together and board and lodge in a *khanaval*. A Maratha woman keeps house and board for them on payment of a fixed sum by each member, ranging from Rs. 12 to 15. The room in which they board is small and insufficient and the boarders generally sleep in passages and verandahs of *chawls* or in public streets. When an illness occurs, one of the men looks after the patient and nurses him; they are averse to hospitals. It can easily be understood how in an infectious disease case, say Cholera, almost all the inmates of the rooms are attacked. During illness, as they cannot

afford milk, they must perforce live on their usual food. In case of Small-pox too, they usually conceal the case. Compared to the Mahars, etc., these people are of cleaner habits, both personal and domestic and not indolent or lazy, and without thieving propensities. From experience during the last decade, it has been found that the Marathas have considerably improved in their personal and domestic habits. They have appreciated the supervision and hygienic conversations organised for them by the Health Department and the Bombay Sanitary Association, and one notices to-day with satisfaction the considerable improvements they have made in their personal habits and in their rooms. It may casually be mentioned here that the housing accommodation for this ever-increasing labour class is not satisfactory.

Mohamedans of the Konkan and the Deccan and of Kathiawar flock to this City, attracted by the higher wages paid for labour. The Konkani Mahomedans work as domestic servants, office *puttavallas*, boatmen, lascars, policemen; the Deccanis aspire higher and take to trades and industries; they, as a rule, earn more than their Konkani brethren and are of cleaner habits. This great Mahomedan labouring class lives in the same manner as the Marathas and under identical unhygienic conditions.

THE "DEPRESSED" CLASSES.

The "depressed" classes consisting of Mahars, Mangs, Bhungis, Chambars and Dheds, whether living in towns or villages, must of necessity live apart, as they are condemned by all Hindus as "untouchables." No other community will live in close proximity to them, because of their habits, thieving propensities and immoral proclivities. In villages they live out, all huddled together, in small dark mud-huts. In towns, they live in *chawls* set apart for these people, or in the open in huts made of wattle and daub and roofing of old kerosine oil tin-sheetings. Their personal habits are very filthy, and they seem to flourish in squalor. Mahars

from times immemorial have been considered essentially hereditary " village servants" : their duties being the removal of dead cattle or other animals, burial of outcastes and removal of offal. They engage also in other occupations, such as rope and basket-making etc. On account of the higher wages they can obtain for labour, they are attracted in large numbers to presidency cities. Here they are employed as dock labourers, coal fillers, and as scavengers by municipalities for the removal of streets and domestic refuse. Many of them also learn different trades and " the village servant of yesterday may be seen driving a motor-car for his private master to-day, amidst the plaudits of the social reformers and the groans of the conservative Brahmins, who still consider that a Mahar's duty is to be an efficient Mahar and wait for his reward in the future stage of existence" !

The individual cost of living is very small indeed. Nothing is prohibited them by caste or religion; anything and everything is welcome from dead meat to the leavings of eating houses, *Mahajan Wadis* and hotels; they live generally in ground-floor chawls in single tenement-rooms, dark, ill-ventilated, damp and overcrowded. The females especially of the Dheds and Bhungis, if not engaged as halalkhores, take to rag and bone-picking. Rag-picking is a great trade with them: to obtain rags they will steal them even from dust bins; they also purchase from servants the bed-clothes and clothing of dead persons. These articles may or may not be from persons who may have suffered from infectious diseases. All these classes bury their dead. The corpse is washed in front of the hut with tepid water and anointed with a mixture of turmeric and ghee; while this is being done, the female relatives wail and caress the face of the deceased, whether the death be from infectious disease or not. The body is then conveyed on a bamboo bier to the burial ground. If death was caused by an infectious disease, the clothes, if the Municipal authorities are aware of the cause, are disinfected and sterlilized. But in most

instances, such cases rarely come to the notice of the Health Department, and the clothes are then simply washed and used again.

Mahars and Mangs are found throughout the Maratha speaking parts of the Deccan and the Karnatak. They appear to be, from their customs and the impurity attached to them, the broken residue of the aboriginal tribes owning the country of which they were dispossessed by successive waves of Aryan and *post*-Aryan invaders. They are regarded by all other castes of standing as "untouchables." They eat sheep, goats, dead cattle, pigs, etc., and drink liquor and live on land set apart for them outside a village.

Dheds are found all over Gujerat, Kathiawar and Cutch. Not unlike the Mahars, they seem to be the remnants of the primitive aboriginal tribes. They eat flesh, fish and also the carcasses of cows, buffaloes, sheep and goats. They eat the leavings of other people and drink liquor. Originally the occupation of Dheds was spinning cotton into thread and weaving cotton cloth, but now they flock to presidency cities and take up the work of the bhangis or halalkhores proper.

Bhangis or halalkhores are found all over India. They are a caste of scavengers and sweepers and are the dregs of Indian society. In Gujerat they are held to be lower and more unclean than Dheds, while in the Deccan they hold the same position as Mahars and Mangs. Both the sexes are employed as night-soil carriers. The Bhangis eat carrion, flesh of cow, buffalo, goat and sheep and eat the leavings of other castes and drink liquor.

Dhors and Chambars: the former deal in cattle skins and are tanners; the latter work in leather and are the suppliers of the foot-wear of the higher classes. These do not eat carrion but flesh of goat, pork, fish, etc. They are a degree higher than those previously described. All these classes indulge largely in country liquor.

CHAPTER XV.

Housing of the Working Classes in Large Cities in India.

The problem of housing and town-planning has developed enormously in England, owing to the passing of the Housing and Town Planning Acts 1890, 1900, 1903, 1909, 1919 and 1925 which deal with (*a*) the extension of existing towns, and (*b*) the improvement and opening up of existing insanitary areas in old towns. The following is a brief outline of the latest English Act.

Housing Act 1925.

Part III.

Provision of houses for the Working Classes.

Section.	
57	Local Authority to provide housing accommodation for working classes.
58	Local Authority to acquire land for the same.
59	Power of Local Authority to lay out streets, open spaces, etc.
60	Duty of Local Authority to prepare housing schemes.
61	Duty of Local Authority to carry out the schemes.
62	Refers to schemes carried out outside the area of Local Authority.
63–66	Deal with the acquisition and appropriation of land.
67–69	Provisions with regard to management of houses etc. provided by Local Authority.
70–71	Provision of houses by Public Utility Societies, Railway Companies, etc.
72	Empowers County Councils to provide houses for their employees.

Section.

73 In case of reported failure to carry out duties by a Local Authority, Minister to make an order.

74 Transfer of obligations from a Local Authority to the County Council.

75 Empowers Minister to act in place of Local Authority

76–77 County Council to act in place of a Rural District Council in case of reported failure.

78 Sale, etc., of land for housing purposes by Corporate bodies.

79 Supply of Gas and Water to houses.

HOUSING, TOWN PLANNING, ETC., ACT 1919.

PART II.

TOWN PLANNING.

42 Removal of necessity to obtain previous authorisation of Ministry to preparation or adoption of town planning scheme.

43 Extension of power of Ministry to make regulations as to procedure.

44 Repeal of provisoes in H. T. P. A. 1909 requiring schemes to be published and laid before Parliament.

45 Power to permit development of estates pending preparation and approval of town planning schemes.

46 Preparation of town planning schemes.

47 Power of Ministry to require town planning scheme.

48 Consequential and minor amendments.

In India, the provisions of Acts and by-laws for the improvement of towns, old or new, are being amended. The Municipal Acts and by-laws were so inconsistent and cumbrous as to render the work of improvement of insanitary areas extremely difficult.

The creation of Improvement Trusts in several cities in India has, to some extent, paved the way for a more serious and enlightened policy.

Attempts at town planning in the real sense of the word are being undertaken in India. Schemes are being prepared to get at the bottom of the real evil, namely, the housing of the working classes and improvement of insanitary areas. Much, however, has been done in the widening of streets, and Bombay of to-day is a vastly different place to what it was in 1898.

The Bombay Municipal Corporation have revised the Building by-laws in respect of open spaces to be maintained for light and ventilation of buildings within the Municipal limits. Two different standards have been fixed, one for each of the two parts into which the City is divided for the purpose of these by-laws. The less thickly populated area where buildings are comparatively scattered, is subject to the standard of $63\frac{1}{2}°$ light and air, and a lower standard is fixed for the remaining part of the City, which is known as the "scheduled" or "congested" area. The $63\frac{1}{2}°$ rule requires that the air planes in the front and the rear of every building, that is, the planes drawn from the top of the front and the rear walls outwards and downwards to the ground at an angle of $63\frac{1}{2}°$ to the horizontal and also at least one of the light planes of every habitable room, that is, the plane drawn from the outer face of the wall at the level of the floor outwards and upwards at an angle of $63\frac{1}{2}°$ to the horizontal shall be left permanently unbuilt upon, subject in all cases to a minimum of 10 feet, except in the case of the front open space which is fixed at a minimum of 15 feet.

The lower standard rule, which ignores the need for free circulation of air in the rear of a building, requires that the whole of at least one side of every habitable room shall face directly or through an open verandah an open (to the sky) space ranging between 10 to 20 feet according to the height of the wall facing the open space, above the level of the plinth.

These by-laws are no doubt a great improvement on those in force before 1919 but the ultimate result of their application in practice is worth watching, as they are based on an assumption, *viz.*, co-operation and goodwill between the owners of neighbouring properties over whom the Municipal Corporation can claim no control.

HOUSING OF THE WORKING CLASSES IN INDIAN CITIES.

"Dwelling-house" includes any yard, garden, out-houses and appurtenances belonging thereto or usually enjoyed therewith.

For census purposes, *a house* is a building under one undivided roof, or having two or more roofs connected *inter se* by subsidiary roofs.

A "*chawl*" means a building so constructed as to be suitable for letting in separate tenements, each consisting of a single room or of two rooms but not of more than two rooms.

According to the last official census (1931) in Bombay, there are 1,97,516 occupied one-room tenements, giving an average of 4.01 persons per room, and no less than 74 per cent. of the population live in one-room tenements.

Working Classes in Bombay.—Forty-nine per cent. of the people of Bombay come within the category of working classes, *i.e.*, about 5,63,000.

Many of the rooms are occupied by more than one family. The rent of these rooms is from Rs. 10 to 12 *per mensem*; the average monthly wages of this class is Rs. 30 per mensem.

INSANITARY CONDITIONS.

The relation between over-crowding and insanitary conditions and a high mortality has been dealt with by all sanitarians from time to time. In cities in India, a high mortality follows closely insanitary surroundings, absence of domestic and personal hygiene, want of ventilation and light and the presence of filth ; in fact, the incidence of disease

is directly related to the insanitary domestic surroundings—the incidence varying with the habits and customs of the people with regard to their food, personal cleanliness, domestic habits, washing, bathing, cleaning of rooms, clothes and persons, habits of living and sleeping ; with accumulation of materials and filth harbouring vermin, condition of floors, of walls and ceilings of houses ; and with prejudice against measures for improvement or any attempt to remove what is considered the cause of the spread of disease.

Insanitary surroundings may then be termed anything or any condition which tends to impair health, and among the chief factors which conduce to it are poverty and ignorance. Of the total influence which these surroundings exert on the health of the people exposed to them, no exact statement can, however, be given. That they produce disease and a certain amount of disablement is undeniable, but it is only so far as the varying incidence of such sickness is ascertained and the disease kills that the effect can be represented in numbers.

Insanitary surroundings may be divided into external and internal. *External* conditions include :—

(1) Sanitary defects in areas, dense aggregation of houses, congested areas and, as a result, inadequate open spaces about dwellings, insufficient light and air.

(2) Dampness of soil.

(3) Want of drainage or defective drainage leading to pollution of soil.

(4) Defective means for removal of excreta and polluted matter, street sweepings, trade and domestic refuse.

(5) Defective sanitary laws and the difficulty of applying them.

(6) Habits and customs of people, religious and other prejudices with regard to exposure of infected persons and things.

Internal conditions have reference to—

(1) Overcrowding in houses and rooms.
(2) Ventilation of rooms.
(3) Dampness of rooms.
(4) Lighting of rooms.
(5) Character of the floor and wall.
(6) Method of collecting rubbish in rooms.
(7) Cleanliness.
(8) The harbouring of vermin on bodies and clothes.
(9) Clothing of persons.
(10) Washing and bathing.
(11) Occupation and habits.
(12) Skin diseases due to climate and clothes and habits inducing facilities for contracting Plague.
(13) Custom in the preparation of food and foodstuffs.

Such insanitary conditions are, as is well known, powerful predisposing causes in the production of Phthisis, Pulmonary Diseases other than Phthisis, Diarrhoeal diseases and Fevers and epidemic diseases generally; and a reference to any satistical table in the reports of various Health Departments all over the world will show that in areas with such insanitary surroundings the sickness and death-rates are considerably above the average, and when those areas have been improved by sanitation, the mortality and sickness, both general and zymotic, have been reduced.

As an illustration of this in Bombay, take one section of the City where sickness and mortality have always been high, *viz.*, Kamatipura.

The streets in Kamatipura are well arranged and fairly numerous, there being sixteen running across it from east to west and five from north to south. There is no uniformity about the houses and they vary much in shape and size. Most of them are sub-let in separate tenements and are

occupied by persons of the poorer classes. Many of these *chawls* are unfit for human habitation, either wholly or in part, owing to radically defective construction.

Overcrowding is undoubtedly the chief cause of the unhealthiness of Kamatipura. This term is applied to two distinct conditions which, however, are invariably associated together. The one has reference to land, upon which the houses are situated in such close approximation that the provision of air, light and space is reduced to a quantity below the standard requirements of health; the other to houses in which the inhabitants exceed in number the accommodation. Both these conditions obtain in an exceptional degree in Kamatipura. The houses are built almost back to back, there being only a narrow passage between the row of houses in one street and that in the next. The depth of houses from front to back is excessive, and usually the whole of the available space behind the street frontage is occupied by the building itself; the privies in many cases are not properly detached and the air of the dwelling is continually charged with the most noisome odours. There is rarely a gully at the sides of houses, and when one exists it is generally not more than two feet in width. As a result of this the buildings as a whole are deficient in light and ventilation, the centre rooms being often in absolute darkness, and dependent for ventilation upon the passages within the houses. Speaking generally, the gullies are open channels for carrying off sullage, but usually they are so imperfectly paved as not to be water-tight, and sometimes they are not laid with a proper fall towards the street drain. Many of them serve as passages for sweepers and are flanked on either side by a long row of privy shafts. In such cases, the trap doors of the shafts abut immediately on the gully, and when the receptacles get full and overflow, as they frequently do, the liquid filth is discharged on the surface of the gully. Refuse of all kinds is also thrown into the gullies by the people living in the adjoining houses. For these reasons the gullies,

though repeatedly cleansed, are generally in a dirty and foul condition, and windows which overlook them have to be kept closed to exclude the smell. Such gullies are therefore of little use for purposes of ventilation. Moreover, owing to the structural defects pointed out above, liquid filth is not carried away but stagnates in the gullies, and the foundations of the houses and the soil around them are continually receiving what to all intents and purposes is the soakage of sewage. In this way the soil and sub-soil are fouled and rendered damp, and the level of the ground water is raised. Throughout Kamatipura this dampness of the soil can be observed, and water is to be found within a few feet of the surface. As a result, dampness of ground floors is a noticeable feature in nearly all the houses, even in those with substantial plinths and paved or cemented floors.

These conditions prevail, though in a modified form, in Calcutta and Madras, Delhi, Ahmedabad and any other large city in India, but in Bombay only are large *chawls* found which are built to economise space, the land being more valuable.

HOUSES UNFIT FOR HUMAN HABITATION.

In dealing with insanitary dwellings, the question of what constitutes a house unfit for human habitation is an extremely difficult one. No scientific standard is or can be applicable. Every sanitary circumstance has to be taken into account. What would be considered unfit in Western countries would be fit in the East where conditions of climate are so different.

According to the Public Health Act in England any dwelling house that appears to be in a state dangerous or injurious to health is considered to be unfit for human habitation.

Under the Bombay Municipal Act, section 378 (amended up to 1918), buildings unfit for human habitation are thus dealt with :—(1) If, for any reason, it shall appear to the Commissioner that any building or any room in a building intended for or used as a dwelling is unfit for

human habitation, he shall give to the owner or occupier of such building notice in writing stating such reason and signifying his intention to prohibit the further use of the building or room as the case may be, as a dwelling and shall by such notice call upon the owner or occupier aforesaid to state in writing any objection thereto within thirty days after the receipt of such notice; and if no objection is raised by such owner or occupier within such period as aforesaid, or any objection which is raised by such owner or occupier within such period appears to the Commissioner invalid or insufficient, he may, with the previous approval of the Standing Committee, by an order in writing, prohibit the further use of such building or room as a dwelling.

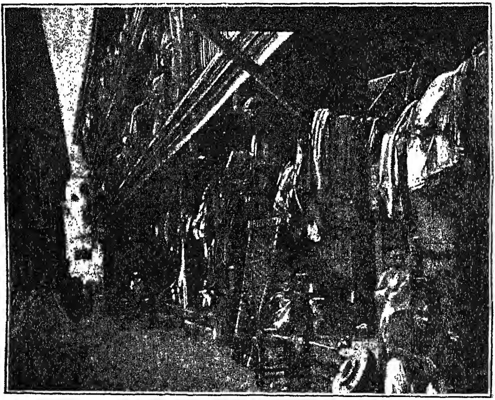
Provided that, before such approval is given, the owner or occupier aforesaid shall have the right of appearing before the Standing Committee in person or by agent and of showing cause why such approval shall not be given.

(2) When any such prohibition as aforesaid has been made, the Commissioner shall cause notice of such prohibition to be affixed to and the letters "U.H.H." to be painted on the door or some conspicuous part of such building or room as the case may be, and no owner or occupier of such building or room shall use or suffer the same to be used for human habitation until the Commissioner certifies in writing that the building or room, as the case may be, has been rendered fit for human habitation.

House inspection.—In dealing with insanitary houses for the purpose of condemning them as "U.H.H." a systematic house inspection must be made.

House inspection has reference to—(1) the arrangements for preventing the contamination of the water supply; (2) the closet arrangement; (3) drainage; (4) the condition of the dwelling house in regard to light, the free circulation of air, dampness and cleanliness; (5) the paving, drainage and sanitary conditions of any yard, compound or out-house

belonging to the dwelling-house; (6) the arrangements for the deposit of refuse; (7) the existence of any room, if it be so dangerous and injurious to health—a room habitually used as a sleeping place which is not on an average at least 7 feet in height from floor to ceiling, or does not comply with such regulations as the local authority may prescribe for the proper lighting and ventilation of such rooms and the protection thereof against dangerous effluvia or exhalations; (8) any defect in other matters which may tend to render the dwelling-house dangerous or injurious to the health of an inhabitant.



IN A TOWN.

Thus in reporting on a house as "U.H.H.," many tenements—single rooms—may be fit, while others may be unfit for all or any of the reasons given above.

The working men and women, for domestic reasons, object to light and air, and it is common to see even the model

Improvement Trust chawls with rags or bags stretched across the windows.

They do not seem to require light or air and we must not consider everything has been done when we have caused every house and room to be rebuilt up to $63\frac{1}{2}$-degree-scale standard.

The only education in sanitary matters these people understand is laws and by-laws, and this is the form education should take in housing the poor.

What the workman is satisfied with is a room $10' \times 10' \times 10'$, a small *verandah*, a *nahani* and a small room for cooking where to stack his wood, cow-dung cakes, pots and pans, and perhaps keep fowls and goats, a loft to store wood or lodge boxes, rags or logs.

More often than not, the cooking is done in the living-room and the smoke escapes into the passages or out of the window. The floor is used for sleeping where circumstances do not permit of a charpoy; the baby is slung in a cot or lies on the floor; the floor is cow-dunged regularly and also the walls. The *nahanis* are misused by the children and for washing and for stacking firewood; the refuse is thrown out of the window. Water is stored in an earthen vessel in the *nahani* and the pots and vessels are cleaned there, or taken out to the street or nearest bathing place. The privy accommodation may be a water-closet or a basket privy, situated at the end of the passage adjoining the common bathing room, which is crowded with men and women fighting for water and washing vessels and their clothes.

In the majority of these dwellings, it is impossible to see in any of the rooms or passages in the day-time or to get through them without a lamp.

TYPE OF WORKING-CLASS DWELLINGS REQUIRED.

For eight months in the year in Bombay, Calcutta and Madras, many people sleep in the open paths, streets, oarts and *wadis*.

The working man in large cities in India could be suitably *housed in a room 10′×10′×10′ for a family man,* wife and two children as the maximum number of inhabitants with a small kitchen separately provided. The room should be so arranged that at least one side should abut on an open space 20 feet in width, well lighted and ventilated, and, if the rooms are in two rows opening into a passage 10 feet wide, they should be provided with a ventilator of at least 3 square feet in area near the top of each of the two walls of such rooms. Such ventilators should be opposite each other. The walls should be of brick, cement-concrete or other impervious materials; the floor, of tiles or cement and stone with a smooth polished surface with rounded corners; a window carried up to the ceiling and made to open, top and bottom, with half doors. The foundation should be of concrete with a plinth 2 to 3 feet high.

The ideal building should be rat-proof, but this ideal cannot be lived up to in a large city in India.

The closet arrangements must be determined by the water-supply and drainage system, but in all cities where such a supply is sufficient for the purpose, the water-carriage system is strongly advocated.

In cities where the water-carriage system is provided, proper accommodation should be given for bathing and washing places in the compound or the space around the building.

If facing the rainy quarters, the rooms should be provided with movable shutters.

The building should not be more than two storeys, ground and first floor; not more *than 20 rooms in each block.* Each block should be at least 20 feet apart and erected in such a position as to have breeze, light and air. The space around the building should be paved with asphalt or tarred.

There should be open space enough for children to play. This can always be arranged in laying out blocks.

The erection of huge blocks of buildings is contrary to the *habits of the people, prejudicial to health and difficult to* control; as a question of expense and owing to the initial cost of land, overcrowding of houses or areas is considered by some as a necessity. From the point of view of the owners of the buildings, this is financially sound; where the land has a value of Rs. 250 to Rs. 500 a square yard, it is easy to imagine that the owner or lessor wishes to reap as much as he can. But in India, even in Bombay, where these houses have been allowed to be built, such excuse should not be tolerated. The erection of such dwellings reduces the value of the locality by over-crowding; they reduce the vitality of the inhabitants and foster disease, thereby reducing the number of workmen available and the amount of labour from each workman.

If certain parts of the city were set aside for erecting dwellings on sites which could be adapted and where land is cheaper, those parts of the city which are now covered with overcrowded insanitary areas could be vacated, a better class of buildings erected with better tenants and would ultimately give better financial results. *For example.*—The dock labourers should be housed near the docks, the mill hands near mills, the general labourers in those parts of the town where land is cheaper; the clerks, etc., on sites easily accessible tram or rail.

The most important section of the Town Planning or Housing Act is for improving old towns. In India it is that referring to the erection of workmen's dwellings and the policy of assisting migration from overcrowded insanitary areas in the expensive part of the city to other sites more remote where fresh air, light and space can be had, where dwellings can be erected cheaply in one-storeyed blocks capable of supervision. The argument against this is that the people will not live away from their work. This is proved to be incorrect in every city where it has been attempted.

The tendency of commercial enterprise is to erect factories, mills and large industries outside of the city proper, where the land is cheaper, rates and taxes less.

POLICY TO BE FOLLOWED.

PROVISIONS REGARDING THE VENTILATION OF BUILDINGS IN TOWNS.

1. *Building sites.*—It should be enacted that every new building or compound in which a building is to be erected must abut on a street of at least 40 feet in width, and where no such street exists, a line must be laid down and the owners of the properties adjoining this line must leave sufficient land for the construction of the street. It should rest with the Municipality to decide whether a new public street should be laid out or not, and in the event of this being done, there should be an obligation to acquire the land left vacant within a fixed period, say two years after the completion of the building, or in default to pay reasonable interest on the value. When the street is to be a private street, the owners of the land must be under an obligation to construct it within a reasonable time in each case. All applications to build, in which the above conditions are not satisfactorily provided for, should be liable to rejection.

2. *Height of buildings.*—It seems desirable in the first instance to provide that, except in the case of specially exempted buildings, such as public buildings or buildings for which special architectural features may be sanctioned, a certain maximum height should not be exceeded; and this should be fixed at 70 feet up to the tie-beam of the roof or place where a tie-beam would ordinarily be. The roof should not be allowed to rise above that at an angle to the frontage greater than 45°. Where the roof is a flat one, a parapet three feet in height may be allowed above the maximum limit fixed. The height of buildings should be further limited according to the width of the street on which they abut, and modern

expert opinion seems to be in favour of prescribing that the height of a house should not exceed the width of the open space in front of it. Rule 3 contained in Schedule XVII to the Calcutta Municipal Act of 1923 seems to be very suitable :—

(1) If a building is situated at the side of a street, no portion of the building, except open or balustrated parapets not more than four feet high, shall intersect any of a series of imaginary lines drawn across the street at an angle of forty-five degrees with the horizontal, such lines being drawn from the side of the street which is the more remote from the building in question, from a height of two feet above the centre of the street :—

Provided as follows :—

(*i*) where the said street is joined at an angle by another street facing the building, or where the street in which the building is situated terminates in front of the building, the height of that portion of the building which is opposite the street facing it measured from two feet above the centre of the street, shall in the former case, not exceed the height which would be permissible if the building abutted on or were situated on the side of a street equal in width to the width of the street on which it abuts or on the side of which it is situated *plus* half the width of the street facing it, and in the latter case, the height of the building shall not exceed the height which would be permissible if the building abutted on or were situated on the side of a street one-and-a-half times the width of the street terminating in front of it ;

(*ii*) nothing herein contained shall affect the erection of a four-storeys building abutting upon, or situated at the side of a street of not less than forty-five feet in width, if such building, including the parapet wall and the plinth, does not exceed fifty-six feet in height ;

(*iii*) nothing herein contained shall affect the erection of a building abutting upon, or situated at the side of, a street of not less than sixty feet in width, if such building does not exceed eighty feet in height ; and

(*iv*) no building exceeding eighty feet in height shall be erected without the special permission of the Corporation who in granting such permission may impose such conditions as they may think proper for the safety of the public and the safety and convenience of persons occupying the building.

Explanation.—If a building be placed at the edge of the street its height measured from two feet above the centre of the street, and excluding parapets as aforesaid, shall not exceed the average width of the street facing the site ; but, if the building, or one or more of its storeys be set back, the height of the building may be increased, subject to the condition that no portion of the building, after the height is increased intersects any of the aforesaid lines.

(2) In the case of a new building erected on any portion of the site of the whole or part of a building in existence at the commencement of this Act, the angle at which the lines referred to in sub-rule (1) are to be drawn shall be fifty-six-and-a-half degrees instead of forty-five degrees :

Provided as follows :—

(*i*) the height allowed under this sub-rule shall in no case exceed thirty-six feet ; and

(*ii*) except with the special permission of the Corporation, nothing contained in this sub-rule shall authorize the erection of a new building so as to make any portion of it higher than any building which at the commencement of this Act was standing on the same portion of the site.

(3) Notwithstanding anything contained in sub-rule (1) or sub-rule (2), the Corporation may, by order published in the *Calcutta Gazette*, declare that, in any street or portion of a street, not less than twelve feet in width, which is specified in the order, the erection of two-storeyed buildings not

exceeding twenty-eight feet in height excluding two feet for the plinth and excluding open or balustrated parapets not more than four feet high, will be permitted without complying with the requirements of those sub-rules.

(4) If a building is situated on a corner plot so as to abut upon more than one street, the narrower of such streets shall, for the purpose of regulating the height of the building, be deemed to be of the same width as the wider street to a distance of fifty-five feet from such wider street.

The Calcutta Building Commission point out that the 45 degree rule has been adopted by the Calcutta High Court as showing what amount of light and air is necessary for the convenient enjoyment of a house. The same standard should be adopted in Bombay and other large cities. In the case of buildings on sites already built on, the limit might be fixed at one-and-a-half times the width of the street, where the height of buildings already existing on such sites is up to that limit at the time of the passing of the new rules.

3. *Exterior open spaces and Interior open spaces.*—It must be obvious to any one acquainted with cities in India that sufficient light and air cannot be obtained from gullies varying from 2 to 5 feet in width, and that where these gullies are used as open drains, as they usually are in Bombay, it is most undesirable to have openings on them. It is unfortunately impossible, from a practical point of view, to attempt to stipulate that no house shall have a depth of more than two rooms to be lighted and ventilated from open spaces on streets at the front and back respectively. Failing this, however, it is essential to make proper provision for the inner rooms. For regulations regarding ventilation of buildings, etc., see pages 42 to 48.

As in the case of the front part of a building, the height of the part at the rear should be limited with reference to the width of the permanently open space on which it abuts and, as provided in the London and Calcutta regulations,

no part of the building should extend above a line drawn at an angle of sixty-three-and-a-half degrees with the plane of the open space, at the level of the plinth, from the boundary of such open space furthest from the building.

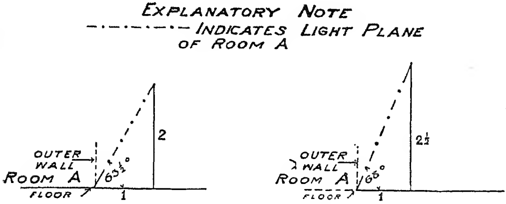
4. *Width of streets.*—The same limit should be prescribed in the case of new private streets or accommodation roads as now obtains in respect of new public streets.

5. *Proportion of sites to be built on.*—In the case of sites used for dwelling houses, the total area occupied by building should not exceed two-thirds of the total area of the site.

6. *Overcrowding.*—In the extension of existing towns or the improvement of insanitary areas, it is very desirable that there should be one standard cf light and ventilation. The standard which has long been enforced upon Improvement Trust estates, and which is also now enforced under Municipal by-laws all over Calcutta, and in the "unscheduled" or less thickly populated areas in Bombay and in most of the important towns in England, is commonly known as the $63\frac{1}{2}°$ standard. Roughly, it means that throughout the length of one side of every living room there shall be external air-space open to the sky extending to a distance, measured horizontally from the room-wall, of at least half the height of the top of the opposite house above the floor of the room. It is called the $63\frac{1}{2}°$ rule, because the angle at which light from the minimum air space so prescribed will strike the floor is an angle of approximately $63\frac{1}{2}°$, which has a tangent of 2 to 1.

Thus, if a gully between two houses is only 10 feet broad, the height of each house above the plinth must be limited to 20 feet, if the lowest rooms are to satisfy the $63\frac{1}{2}°$ rule and if two houses of the maximum height ordinarily allowed in Bombay, *viz.*, 70 feet, are built side by side and have side rooms depending upon the space between the houses for their light and ventilation, then to satisfy the $63\frac{1}{2}°$ rule that space must be 35 feet broad.

Not more than one family should be allowed to reside in each room; for each adult a floor space of 25 superficial feet and for each child under 10, a floor space of 12½ superficial feet should be required, and for each adult a cubical space of 250 feet, and for each child under 10, a cubical space of 125 feet, exclusive of any part of the room more than 10 feet from the floor, should be enforced.



7. *Certificate of completion.*—Within a reasonable time after the completion of any building, the owner should be bound to give intimation to the Commissioner and should give all necessary facilities for inspection within a month after the intimation is given. If, on inspection, it is found that the work has been done in accordance with the sanction and so as not to contravene any of the provisions of the Act or by-laws, a certificate permitting the occupation of the building should be given. If these conditions have not been fulfilled, there must be power, as at the time of construction, to require the necessary alterations to be made.

CHAPTER XVI.

Vital Statistics.

Vital statistics may be defined as the science of figures applied to the health history of communities.

They deal with the principal events or phenomena of human life; births, marriages and deaths, the various diseases from which people suffer or die, together with the influences which affect vitality. In other words, the units of which they are composed consist mainly of persons living and of persons dying, and these units are classified or grouped under certain characteristics, such as age, sex, occupation, disease, etc.

The analysis of these units or elementary facts observed in their various relations to time and place, and dealt with according to strict numerical method lies at the foundation of all sound enquiry and supplies the only true criterion of sanitary progress.

The collection and publication of vital statistics serve in a considerable degree to stimulate public interest in, and attention to, matters affecting the public weal, and in the hands of health authorities they direct attention to the health of the people and conditions which adversely affect it, thus enabling precautions to be taken and, in respect of trades, attention being early directed to any particularly dangerous ones, subsequent investigation then suggesting the lines on which preventative legislation should be based.

Statistics of sickness, as opposed to mortality, have not as yet been attempted on a large scale on account of the difficulty of collecting data. Such returns would be of great value in helping the solution of the problem of the influence of varying conditions of soil, climate, season, prosperity, race, etc.

At present, however, compulsion is exercised only in respect of certain dangerous infectious diseases, so as to enable the authorities to take measures for the prevention of the spread thereof.

Vital statistics may be termed the statistics of life, *morbidity* statistics those of disease and *mortality* statistics those of death.

Vital statistics in India, except in a few of the larger towns are of little value as an index to the real health conditions of the country. Even in Bombay, Calcutta and Madras where laws exist for regulating the registration of births and deaths and sickness, elaborate systems have to be employed for collection and verification, owing to defects in the particular law and the ignorance or resistance of the people to voluntarily report deaths, births and sickness.

The methods employed in other countries in the compilation of statistics cannot be relied on in India as an accurate basis for calculation, and no comparison can be made between Eastern and Western figures. Except in the larger cities mentioned, the fallacies of averages and rates are greater. For these reasons the causes given for an increasing death-rate or diminishing birth-rate or an increasing population in Western countries do not apply equally to the East. The circumstances of early marriage, pestilence and famine, Plague and Cholera, a high birth-rate and conjugal condition have to be considered in the East.

In India, women practically begin child-bearing at a very early age and, the birth-rate being high, the increase in the population is kept in check by the enormous infant mortality. No prudential motives enter into the domestic life of the ordinary Indian, the checks on the population being pestilence and famine, a high infant mortality, premature birth, unskilled midwives and insanitary surroundings, poverty, ignorance and superstition.

SOURCES OF INFORMATION FOR THE SANITARIAN.

For the purposes of the sanitarian, the main sources of information are the census, the returns of marriages, births and deaths, the notifications made under the various Notifications of Infectious Diseases Acts, and the returns made under the Factory Act relative to poisoning from certain metals, *etc.*, *e.g.*, lead, arsenic, mercury, phosphorus, and the disease Anthrax. As all these returns particularise the locality of each unit, whether supplied by census or by registration or notification the units themselves can be readily classified according to the various divisions or sub-divisions of the country, such as districts, talukas, towns, villages, and streets.

The essential basis of all vital statistics is the possession of an approximately accurate knowledge of the population.

This can only be obtained by taking a census of the people.

THE CENSUS.

In taking a census it is desirable in so far as possible to select a time when the greatest number of residents will be at their homes, avoiding holiday periods, etc.

It need hardly be stated that the taking of a census is not confined to merely taking a count of the number of people. Amongst other items the schedule records particulars of the name, sex, age, occupation, relation to the head of the family and place of birth of every person passing the night of the day selected for the enumeration in every house throughout the land.

In England the census was first taken in the year 1801 and has been taken every tenth year since that date. It is usually taken at the end of the first quarter of the first year of a decade, *e.g.*, 1921, 1931.

In very few places is the population found to be stationary; it usually increases or decreases; if no such

variation took place, then, of course, the number found at the last census would be correct for intercensal years.

In practice, however, it is usually found to be necessary to calculate the number of people estimated to be in existence for the years and fractions thereof between the censal years.

An intercensal interval of ten years is really too long and, if accuracy of information is desired, the enumeration should occur at shorter intervals.

At whatever interval it is taken, however, certain errors are liable to occur in the returns, especially in regard to age and occupation; the former error may arise from real ignorance thereof—or from a desire to under-estimate the real age—or from over-estimating it either from a desire for local notoriety or with the object of benefiting under any provident or national pension scheme.

The returns of occupation are also sometimes misleading as no distinction is made between employer and employee; the former may never have engaged in the active pursuit of the particular trade under which he is returned or, at any rate, not for many years, and the inclusion of such as these tends to vitiate the returns. Again, although the instructions are most explicit, a certain number of individuals are counted twice over, if they happen to be away from their homes on a visit, as through ignorance or carelessness they are counted in both places. Again a few are altogether overlooked.

Any increase in the recorded population may be either natural or actual. By a natural increase is meant the excess of births over deaths in any place in a given period of time; whereas an actual increase depends on the balance between births and immigration on the one hand, and deaths and emigration on the other. As a general rule, in towns, the actual increase is greater than the natural, owing to the tendency of people to migrate from rural districts into towns for employment. The actual increment can only be ascertained by a census. It must be remembered that

the rate of increase or decrease of population in any particular portion of a town cannot be considered as indicative of a similar rate for the town as a whole, as there is a growing tendency to migrate to new houses in suburbs, and consequently houses in the centre of the city, which were formerly used as residences, become merely offices, etc.

The average rate of natural increase shows wide variations in the several countries of the world, as shown below:—

Country.	Natural increase per 1000.
Australia	12·2 (*a*)
New Zealand	11·5 (*a*)
Italy	13·5 (*b*)
Spain	10·5 (*b*)
Germany	7·5 (*b*)
North Ireland	6·7 (*b*)
Scotland	6·3 (*b*)
Belgium	5·6 (*b*)
England and Wales	4·6 (*b*)
France	1·5 (*b*)
Japan	14·6 (*b*)
Canada	14·4 (*b*)
U. S. America	8·7 (*b*)

(*a*) = 1930. (*b*) = 1925-28.

The average annual rate of natural increase in England and Wales in the four years 1925-1928 was 4·6 per 1,000 of the total population. Taking this figure as a criterion, it will be seen that in proportion to total population the natural increment was above that rate in all the countries mentioned in the table above, except France.

From the Annual Report of the Sanitary Commissioner with the Government of India for 1921, it is noticed that the ratio of births to population was 31·97 and deaths, 30·59, giving a natural increase of 1·4 per 1,000 of the population.

II.—Actual Increase in population in different countries.

Countries.	Annual increase per cent. in							
	1891–1896.	1896–1901.	1901–1906.	1906–1911.	1911–1916.	1916–1921.	1921–1926.	1929.
Australia	1·86	1·49	1·38	2·03	1·95	1·99	2·09	1·21
New Zealand	2·41	1·98	2·86	2·56	1·61	2·32	1·95	1·24
England and Wales	1·15	1·15	1·04	1·04	— ·95	1·89	·62	·32
Scotland	1·06	1·06	·55	·56	·31	·24	·09	·08
Ireland	— ·60	— ·43	— ·22	— ·06	— ·21	·58	— ·60	·33
Belgium	1·15	·95	1·26	·69	·54	— ·56	1·03	·80
France	·09	·24	·15	·06	— ·72	·55	·76	·15
Germany	1·17	1·51	1·46	1·36	·71	—1·62	·73	·58
Italy	·68	·61	·52	·80	1·16	·22	·91	·82
Spain	·45	·45	·52	·87	·66	·82	·65	....
Japan	·96	1·25	1·29	1·08	1·42	·37	1·42	1·51
Canada	·97	1·19	2·99	2·99	2·20	1·81	1·33	1·43
U. S. America	1·93	2·02	2·00	1·82	1·67	1·21	1·67	1·01

There are certain terms used in connection with populations which should be explained.

The *effective population* is that between the ages of 20 and 70.

The specific population means the number of persons per acre or per square mile. It is also called *density of population.* This was formerly believed to be a question of considerable importance, but the significance lies really not in the number of persons per acre or per square mile so much as in the number of persons per occupied room on that area.

Absolute Population.—This means the total population of any country or place.

FLUCTUATIONS IN POPULATION.

Populations are constantly changing. In some countries *e.g.*, the United States, Africa, New Zealand, Canada, Australia and certain South American countries, considerable numbers of individuals are annually being added by immigration and there is a continuous diminution by reason of emigration in some European countries.

Migration not only may affect the population of a country as a whole but also may alter the distribution of people within a country.

There is in many countries a constant movement of people from rural localities to the cities and from one locality to another.

All populations are also being increased by births and suffering losses by deaths. The rate of change, however, resulting from these two causes is usually comparatively constant or alters gradually, while the changes due to migrations may be exceedingly irregular.

The frequency of births, marriages and deaths is usually expressed as the number occurring during the calendar year per 1,000 population. The figures thus obtained are known as

the birth, marriage, or death-rates and are computed upon the mean population, *i.e.*, the number of inhabitants estimated to have existed at the middle of the year.

Since during the intercensal periods the population is not stationary, it is necessary to calculate the estimated population at any given date during the period.

ESTIMATE OF POPULATION.

For the making of estimates there are two methods commonly used, known respectively as the arithmetical and the geometrical methods. In each case the populations at the last two census enumerations form the known quantities from which the estimates are derived.

Arithmetical method.—In the arithmetical method, it is assumed that the increase or decrease in population which occurred between the last two census enumerations took place in equal amounts during each intercensal year and will continue to take place annually in like numbers until the next census shall have been taken. Thus, given a city which had a population of 50,000 at the 1910 census (June 1, 1910) and one of 61,850 at the 1920 census (April 15 1920), the increase during the intercensal period (9 years and $10\frac{1}{2}$ months) would be 11,850 and the annual increase according to the arithmetical method would be.

$$\frac{61{,}850—50{,}000.}{9\frac{21}{24}} \text{ or } 1{,}200.$$

If it is desired to estimate the population as on July 1 1916, for the purpose of calculating annual rates, this is done by adding to the population as it existed on June 1, 1910, the sum of 1,200 for each year intervening between the date of enumeration (June 1, 1910) and the date for which the estimate is to be made (July 1, 1916). There being 6 years and 1 month between these dates, the calculation would be

$$50{,}000+(6\tfrac{1}{12} \times 1{,}200) = 57{,}300.$$

This same annual increase is also assumed to occur until the next census shall have been taken, so that if it is desired to estimate the population for July 1, 1924, take the population at the preceding census (April 15, 1920) and add 1,200 for each year intervening between its enumeration and the date for which an estimate is desired (July 1 1924). There being 4 years and $2\frac{1}{2}$ months between these dates, the calculation would be

$$61{,}850+(4\tfrac{5}{24}\times 1{,}200)=66{,}900.$$

This method assumes the same amount of increase each year and is analogous to the calculation of simple interest. It does not take into account the fact that, with the annual increase in population, the number of persons of marriageable age, and therefore the number of married persons, will be greater each year and consequently the number of births. The growth due to natural increase (the excess of births over deaths) is analogous to the increment of compound interest, and where this factor (the natural increase) is the principal one affecting the population-growth, estimates of population made by the arithmetical method are unsatisfactory, and especially so where the estimate is made for a date several years away from a census enumeration.

Where the excess of births over deaths is the controlling factor in population growth, the geometrical method is more accurate. Where the chief factor in population-change is migration, or where the relative importance of natural increase is much affected by migration, the arithmetical method may be more accurate. This latter method is the one used by the Census Bureau in the United States.

The geometrical method is used by the Registrar-General of England and Wales.

When the births exceed the deaths and the ratio of the births and deaths remains constant, then the population increases in regular geometrical progression.

Thus, suppose the birth-rate of a population numbering 5,000 is 30 per 1,000 and the death-rate is 20 per 1,000, and that these rates remain constant for 10 years, then the annual rate of increase is 10 per 1,000 or 0·01 per unit, *i.e.*, one person becomes 1·01 at the end of a year or 1,000 become 1,010; thus the population at the end of the 10th year will have become $5{,}000 \times 1{\cdot}01$ or 5,523 persons. For, the population at the end of the 1st year$=5{,}000 \times 1{\cdot}01$, at the end of the second year it is $5{,}000 \times 1{\cdot}01 \times 1{\cdot}01$, etc.

These calculations are more easily performed by the use of logs., *e.g.*, estimate the population of a town in June 1914, whose population in March 1911 was x.

In order to do this, it is necessary to know the population at the previous census, *viz.*, 1901, so as to calculate the increase or decrease during the previous decade.

Now to estimate the population in June 1914, *i.e.*, $3\frac{1}{4}$ years after the census, proceed as follows.

Take the log. of the 1911 population and also that of the 1901, subtract the lesser from the greater and the result equals the log. of the 10 years' increase or decrease.

Divide this by 10 and we get the log. of the annual increase or decrease, and this divided by 4 gives the quarterly increase or decrease.

To find the population required, add to or subtract from the log. of the 1911 population (*a*) the log. for the annual increase or decrease $\times 3$, and (*b*) the log. for the $\frac{1}{4}$ year's increase or decrease; and from the final log. thus obtained calculate the number corresponding, which number will be the estimated population.

It must be remembered that the official method of estimating population on the assumption of an equitable rate of increase or decrease is even approximately trustworthy in the case of very large communities only as, in such, any abnormal variation in one direction is more likely to be

counterbalanced by another in the opposite. In small communities, where growth is often spasmodic and irregular, such estimates cannot be relied upon.

There are two unofficial methods of checking estimated populations :—

(1) A method advanced by Newsholme: Assuming the birth-rate to remain the same as at the last census, *then from the total number of births one* can calculate the population thus :

The average birth-rate=35·68 per 1,000 and the total births=7,582, then the population$=\frac{7,582\times 1,000}{35\cdot 68}$ =212,500.

(2) From the number of inhabited houses and the average number of persons per house found at the last census, *e.g.*: Average number of persons per house was 6·2 and the number of houses inhabited in 1898 was 13,240, then, provided the house rate is the same, the population would be $6\cdot 2\times 13,240=$ 82,088. This method of estimating is not so reliable as it was formerly, owing to the change in the habits of the people. The modern tendency to live in flats and large hotels is liable to upset calculations, as is also any alteration in the type of house, *e.g.*, when rows of villa houses are replaced by streets of attached houses.

BIRTHS, MARRIAGES AND DEATHS.

Birth statistics are of interest mainly because of their relation to population growth, the excess of births over deaths being known as the natural increase. The data from which birth statistics are compiled are obtained by registration, and it is desirable that the essential information which is required to be registered should include the name and sex of the child, date and place of birth, whether born alive or still-

born, and the names and residence of the parents. Additional information in the following direction would be of value : age, colour and occupation of the parents, whether the child is a single birth, a twin, or triplet, and whether legitimate or illegitimate.

There are several ways of expressing the birth-rate.—

(i) It may be expressed as the number of births occurring during the year per 1,000 of the population.

This is known as the crude birth-rate and is based upon the total estimated mean population for the year, and includes all ages and both sexes.

To obtain this crude birth-rate ; multiply the total number of births during the year by 1,000 and divide by the population at the middle of the year. This rate shows the net result to the community of the several facts governing reproduction : the number of women of child-bearing age, the number of those who are married ; the frequency of illegitimacy. It is a satisfactory basis for comparing the birth rate of different years for the same community or that of different communities having populations of similar composition.

It is unsatisfactory for the comparison of populations having different proportions of females of child-bearing age or of married women : a mining town or a new industrial centre may have comparatively few women ; a fashionably residential district may have a relatively large female population, most of which may consist of unmarried servants.

(ii) A fairer and better method would be to express the rate as the number of births occurring during the year per 1,000 of women of child-bearing age. For this purpose women between 15 and 45 are

included. This method, which is expressed as one birth per so many women, enables more accurate comparisons to be made between one country and another than the first method which gives what is known as the crude birth-rate. The births registered in the United Kingdom in the year 1931 numbered 632,081 and were in the proportion of 15·8 per 1,000 of the population at all ages. This rate was 0·5 per 1,000 above the corresponding rate in 1930. Compared with the average in the ten years 1921-1930, the birth-rate in 1931 showed a decrease of 2·5 per 1,000.—

Countries.	Birth-rate per 1,000 living.						
	1901-05.	1906-10.	1911-15.	1916-20.	1921-25.	1926-30.	1931.
England and Wales.	28·2	26·3	23·6	20·1	19·9	16·7	15·8
Scotland	29·2	27·6	25·4	22·6	23·0	19·9	19·0
Ireland	23·2	23·3	22·7	20·5	21·4	20·2	20·0
Total ..	26·9	25·7	23·9	21·1	21·4	18·9	18·3

In Great Britain in the year 1876, the birth-rate attained the highest point on record, *viz.*, 36·3 per cent.; since this date the rate has fallen year by year with a few insignificant exceptions, until in the year 1931 it was only 15·8 per 1,000.

The birth-rate is higher in towns, because there is a higher marriage-rate and women marry at an earlier age and, moreover, there is greater infantile mortality. Further, urban districts have a greater proportion of women of marriageable age. One of the main factors determining the birth-rate should be the marriage-rate, not the marriage-rate of the same or even of the next preceding year, but the combined rates of several years. Commercial prosperity increases

the birth-rate, owing to an increased number of marriages. The birth-rate is high in mining districts and large industrial centres; and, as a rule, it is high among the poor. As we have seen, the birth-rate in England is falling and there is at present no indication of any real check in the decline: but this decline is not confined to England by any means, as it is a feature common to nearly all European countries and also to the principal colonial states.

The following table demonstrates this point clearly:—

ANNUAL BIRTH-RATE PER 1,000 PERSONS LIVING.

Countries.	1901-1905.	1906-1910.	1911-1915.	1916-1920.	1921-1925.	1926-1930.
England & Wales ..	28·1	26·2	23·6	20·1	19·9	16·7
Austria	35·6	33·7	26·8	16·8	22·2	17·6
Belgium	27·7	24·6	20·9	14·8	20·5	18·5
France	21·2	19·9	17·2	13·2	19·4	18·2
Germany	34·3	31·6	26·3	17·9	22·1	18·4
Hungary	37·2	36·7	32·2	21·8	29·4	25·8
Italy	32·6	32·7	31·4	23·0	29·2	26·3
Norway	28·6	26·3	25·0	24·6	22·0	17·9
Spain	35·0	33·6	30·8	29·0	30·2	29·2
Switzerland	28·1	26·0	22·7	19·1	19·5	17·5
New Zealand	..	..	26·0	24·3	22·2	19·8
Japan	31·7	32·7	33·5	33·0	34·6	33·9

Apart from fluctuations in the marriage-rate, there are other factors at work tending to a decrease in the birth-rate, chief amongst which is the deliberate prevention of conception. The effect of the fall of the birth-rate on the growth of the population has been, to some extent, modified by the

concurrent fall in the death-rate, but obviously this fall in the death-rate cannot continue indefinitely, and, other factors being equal, the results of the next census will show a further reduction in the proportion of children in the population. The proportion of male to female children born is as 104 to 100, but before the end of the second year the figures approximate owing to the greater mortality among male infants. There is a greater tendency towards male births in large families and among the early born than the late born.

Amongst other causes of the decreased birth-rate must be reckoned the general tendency towards postponement of marriage to a later age and the diseases of sex which appear as a concomitant to postponed marriages. Again, there is a definite diminution of desire for offspring, because of competing pleasures and of increased strain of the struggle for existence, resulting in an increase of mental and nervous diseases in general. A high infant death-rate is usually accompanied by a high birth-rate, and conversely, a low infant death-rate by a low birth-rate.

The illegitimate birth-rate is usually reckoned in the same way as the birth-rate, *i.e.* as a proportion to every 1,000 persons living. It is occasionally stated as a proportion to the total births, but this is misleading, as the total number of births varies as the marriage-rate, and this is greatly dependent on the activity of trade; consequently, if trade is depressed, the marriage-rate is low and the proportion of illegitimate births appears unduly high. A more accurate method would be to reckon illegitimate births as a proportion to every 1,000 unmarried women at childbearing age, *viz.*, 15 to 45. The illegitimate rate varies in different countries and districts. There is probably no single explanation of the wide variations in the rates of illegitimacy, but differences of religion, of social conditions, of race and of the

marriage laws particularly in regard to the possibility of legitimization by subsequent marriage, must all be taken into account.

Sources of error in birth statistics : The principal sources of error are to be found in defective registration. There is no reliable check by which failure to register births can in all cases be detected.

The registration of illegitimate births is always less complete than that of the legitimate.

MARRIAGE-RATES.

The crude marriage-rate can be obtained, like the birth-rate, as the proportion of persons marrying per 1,000 of the population living in the middle of the year. This rate is useful for comparing the rates of marriage in a population from year to year, but it is not adapted for comparisons extending over a long series of years because it takes no account of the effects of changing constitution of a population, nor is it well adapted for comparing the rates in two or more communities because of the difference in the sex and age constitution of the respective populations. In view of this changing constitution, a better method of measuring the rate would be to eliminate the married persons and young children and to calculate the rate on the unmarried and widowed portion of the population, aged 15 and upwards, so dealing with that section of the population only in which marriages take place. A still more precise method would be to take account not only of the changes in the proportion of marriageable persons, but also of the changes in their ages. A difficulty, however, arises in attempting to make such a calculation owing to the comparatively high proportion of unstated ages in the marriages of earlier years. On the assumption, however, that an approximation to the number of marriages in each group may be obtained by distributing the unrecorded ages, in the same proportion as the recorded, a rate has been cal-

culated by the Registrar General for the period of 1876-1880 based on the age constitution and proportion of marriageable persons, women, in the census of 1901. Taking this corrected rate as a standard, the marriage-rate in 1908 when compared with the rate for 1876-1880 shows a fall of 15·4 per cent.

The marriage-rate is always higher in towns than in rural districts, because a number of young country people go to the towns for work and there marry. Moreover, in towns there is always an excess of young people of marriageable age. Trade also influences the number of marriages: if good, the number increases. The increased competition in life, the higher standard of living and education, and the desire for personal comfort, in combination with the increased price of many of the necessities of life, have all exercised their influence in bringing about a decline in the marriage-rate. Not only has there been a decline in the rate, but the average age of marriage is gradually rising. This is reflected in fecundity of the marriage, as this is influenced by age, especially the age of the wife. Since 1873 the mean age at marriage has gradually risen in England. The age of maximum fecundity is for men 25-26 and for women 18-19. In England the average number of children per marriage is 4·5.

In India the marriage-rate based on the number of persons married to the *total population returning civil conditions* was 452·35 per 1,000 of persons according to the census of 1921 and 582·5 according to that of 1931.

DEATH-RATES.

The death-rate may be expressed either as a proportion to every 1,000 of the mean population, or as one death per so many living. In order to obtain the general or gross death-rate (annual), it is necessary to multiply the number of deaths by one thousand and divide by the population at the middle of the year, *e.g.*, if the population be 20,000 and the deaths during the year amount to 400, then

$\frac{400 \times 1,000}{20,000} = 20$ per 1,000. When the returns are required for a shorter period than one year, a different method has to be adopted : one may desire weekly or monthly rates and these rates represent the number of deaths that would take place per 1,000 of the population in a year, if the proportion of deaths to the recorded population in these shorter periods were maintained throughout the year. The correct number of days in a year is 365·24226 and of weeks is 52·17747. The birth-rate or death-rate may be accurately calculated from weekly, monthly and quarterly returns, as follows :—To estimate *weekly* rates :—

$$\frac{\text{number } \textit{of deaths during the week} \times 52.17,747 \times 1,000.}{\text{Population}}$$

Monthly rates are obtained thus :—$\frac{\textit{Number of deaths in 4 weeks} \times 13 \times 1,000}{\text{Population}}$.

Quarterly rates thus :—$\frac{\textit{Number of deaths in the quarter} \times 4 \times 1,000}{\text{Population}}$.

There is another way in which these rates can be arrived at.

First ascertain what may be called the 30 or 31 days population of the town or district in this manner, *e.g.*, the population equals 643,148=Log. 5·8083109. The number of days in a month equals 31=Log. 1·4913617 and the number of days in a year 365=Log. 2·5622929, then—

$\frac{\textit{The population} \times \textit{the number of days in a month under consideration}}{365}$ equals the 31 days population, equals Log.

4·7373797. Now, the death-rate equals the $\frac{\text{deaths} \times 1{,}000}{\text{Population}}$; therefore, if in the above example the deaths were 785, then $\frac{785 \times 1{,}000}{\text{Population}}$ equals $\frac{\text{Log. } 5\cdot8958697}{\text{Log. } 4\cdot7373797}$ equals Log. 1·1574900=14·37 the death-rate.

The following tables give the crude annual death-rates per 1,000 living in the countries mentioned :—

Countries.	Death-rates.							
	1901-1905.	1906-1910.	1911-1915.	1916-1920.	1921-1925.	1926-1930.	1931.	1932.
England and Wales ..	16·0	14·7	14·3	14·4	12·2	12·1	12·3	..
Scotland	17·1	16·1	15·7	14·9	..	..	..	..
Ireland	17·6	17·2	16·8	16·6	..	..	..	..
United Kingdom	16·3	15·1	14·7	14·8	..	..	..	..
India	33·1	34·8	30·1	38·2	26·6	26·9	..	..
Bombay Presidency ..	38·7	30·5	29·1	44·7	25·3	28·4	..	..
Bombay	64·1	40·8	32·9	48.3	32·9	21·8	21·6	19·7

Countries.	Quinquennial period.	Death-rate.
New Zealand	1923–27	8.6
Australia	1923–27	9.5
Canada	1922–26	11.1
Norway	1922–26	11.3
Sweden	1922–26	11.9
U. S. America	1921–25	11.9
England and Wales	1923–27	12.0
Belgium	1922–26	13.2
Germany	1922–26	13.4
Scotland	1922–26	13.7
Austria	1921–25	15.7
Italy	1923–27	16.5
Spain	1922–26	20.0
Japan	1922–26	21.2
Russia	1921–25	25·8

The above death-rates are known as the *general* or crude death-rates. These have to be subjected to correction

according to the age and sex distribution of the population. Correction for age is necessitated, because the death-rates for the age-periods between 5 and 55 are lower than those for ages below 5 and above 55. If therefore in any district there is, compared with some other district, an excess of population between 5 and 55, there will be a lower death-rate, because of this less liability to death at these age periods; this liability reaches a minimum at the 10-15 age-period and thereafter rises steadily throughout life. In many towns there is a considerable immigration of young adults seeking employment and, moreover, most towns contain a smaller proportion of people of great age, as many of them retire to the country to spend their later days. Correction for sex is necessary because, as a class, females live longer than males, the death-rate among the latter being uniformly higher except at ages 10 to 20. In many towns, especially seaside and watering places in England, there is a large influx of young adult women of the servant and waiting-maid class, among whom the liability to death is comparatively small. These facts tend therefore to lessen the true death-rate of the place and, to allow for this and obtain a more correct death-rate, the Registrar-General of England devised a method by which the crude death-rate of the large cities and towns of England and Scotland could be made comparable to that of England and Wales generally. This new rate is known as the corrected death-rate. The method consists in estimating a series of factors by which the crude rate is multiplied, resulting in a raising or lowering of that rate to what it would be if the age and sex population of that particular town were the same as in England and Wales as a whole.

The factor is obtained in the following manner. In the first place it is necessary to calculate the *index death-rate* of the population under consideration. This is a death-rate calculated on the hypothesis that the mortality of the

population at each age-period and for either sex corresponds to that obtaining in the country as a whole.

The population is classified separately by sexes in quinquennial age-groups and for the purpose of calculating the *index death-rate* of the district or town in question, it is assumed that those living in each of the groups will die at the same rate as those dying in the similar age-periods in the country generally; and thus a hypothetical number of deaths is arrived at on the basis of applying the death-rates of the country at different age-periods to the population under consideration.

Thus the

$$\text{Index death-rate} = \frac{\text{Total deaths thus calculated} \times 1{,}000}{\text{Population}},$$

and from this we can ascertain the factor for that particular town.

$$\text{Factor} = \frac{\text{Death-rate for the whole country}}{\text{Index death-rate of the town}}.$$

Example :—

The population of a country as divided into quinquennial age-groups and different sexes with the mortality rates for different ages and sexes are as given below :—

Population of the Province.			Death-rates per 1,000 of Males & Females and according to Age-groups.	
	Males.	Females.	Males.	Females.
0—5	34,710	33,922	296	291
5—10	46,404	41,628	25	29·5
10—15	55,713	35,670	17	23
15—20	69,822	40,459	24	30·5
20—30	2,36,661	1,13,064	22	27
30—40	1,95,233	72,073	20·5	28·5
40—50	84,966	36,148	31	34
50—60	32,276	19,068	65	64
60 and upwards ..	15,547	12,550	157	194

Death-rate of the country is :—45·58.

Similarly the population of a town in the country divided into age and sex groups is as follows:—

Population of a Town.

	Males.	Females.
0—5	677	670
5—10	732	690
10—15	755	601
15—20	589	478
20—30	1,162	1,081
30—40	1,000	814
40—50	647	573
50—60	407	366
60 and upwards ..	280	302
	6,249	5,575
	5,575	
Total	11,824	

Total deaths calculated in the town according to death-rates of the different age and sex groups of the country.

M.	F.
200	195
18	20
13	14
14	14
26	29
20	23
21	19
26	23
44	58
382	395
395	

777 deaths.

Index death-rate is calculated thus :—

11,824 .. 1,000 777 =65·7

The Index death-rate for the town is 65·7 per 1,000.

$$\text{Factor for correction} = \frac{\text{death-rate of country}}{\text{death-rate of town}} = \frac{45{\cdot}58}{65{\cdot}7} = {\cdot}7$$

The recorded death-rate of the town is 31·02 per 1,000.

The corrected (standardised) Recorded death-rate × death-rate would then be × Factor for correction.
=31·02 × ·7=21·7.

Owing to the proportion of persons of low mortality (young adults and females) being excessive in most towns, their recorded death-rate is too low and consequently their factor is above unity and therefore their recorded death-rate reads at a lower figure than the corrected. Corrections are also made for non-resident persons. As a general rule, deaths in large public institutions, such as asylums, prisons, hospitals, workhouses, etc., are relegated to the district from which the individual came. To do otherwise would result in unfairly raising the death-rate of a town in which one or more of these institutions happened to be located.

In India no factors exist for age and sex correction, and the term corrected death-rate as applied to the Bombay City statistics is merely indicative of the fact that all deaths of individuals, whose residence in the City has not exceeded 10 days, have been excluded.

There are certain other terms applied to death-rates to which it is necessary to refer.

Combined death-rate.—By this is understood the mean death-rate of two populations, perhaps adjoining; the estimation thereof is a frequent source of error to students, usually arising from failure to take into consideration the proportion which the two populations bear to one another, *e.g.*, if two towns were of equal population, say 30,000 and

the death-rate of one was 22 and of the other 16, then the combined death-rate is $\frac{22+16}{2}=19$ per 1,000; but if the towns have a dissimilar population, *e.g.*, 42,000 and 18,000 and the respective mortalities were 22 and 16, then A with 42,000 population and a death-rate of 22=924 deaths, and B with 18,000 population and a death-rate of 16 gives 288 deaths: that is to say the combined populations, *viz.*, 60,000 give 1,212 deaths, then $\frac{1{,}212\times 1{,}000}{60{,}000}=20\cdot 2$, the true combined death-rate.

SPECIFIC DEATH-RATES.

Special or specific death-rates are the rates of specified or limited sub-groups of the population. These latter may be obtained by dividing the population according to sex, age, race, social condition, occupation and so on.

They may be stated as the proportion of the number of deaths per annum in the sub-group per 1,000 of the mean annual number of the population in that sub-group.

Among the more important specific death-rates are those relating to age-groups, race-groups and sex.

THE COMPARATIVE MORTALITY FIGURE.

If the corrected death-rate in each town be compared with the recorded death-rate at all ages in England and Wales taken as 1,000 we get a number known as the comparative mortality figure, or expressed in another way, after correcting the gross death-rate of a town for age and sex, the same number of people that gave 1,000 deaths in England and Wales gave—? for that particular town.

The comparative mortality figure is obtained thus—

$$\frac{\text{The corrected death-rate} \times 1{,}000}{\text{Death-rate of England and Wales.}}$$

This implies that, after making allowance for age and sex distribution of the population, the number of persons that in England and Wales furnished 1,000 deaths, in the particular town under consideration furnished so many; *e.g.* for Huddersfield in 1897 the death-rate was 19.07 and that for England and Wales was 17.43. The comparative mortality figure, therefore, was

$$\frac{19{\cdot}07 \times 1{,}000}{17{\cdot}43} = 1{,}094.$$

∴ the number of living persons that in England and Wales furnished 1,000 deaths, actually furnished 1,094 in Huddersfield.

FACTORS AFFECTING DEATH-RATES.

Death-rates are affected not only by the statistical methods used in their preparation and by the age, sex, and race composition of the population, the social, marital, and economic status of the people, the nature and conditions of employment and the adaptability of a people to their environment, but also in limited areas by a number of other factors, such as the location of hospitals and institutions.

(1) *Migration.*—Migration affects death-rates by changing the age, sex, or race composition of the populations. Migrants are likely to consist more largely of males than of females, of young adults than of the extremes of life. The effect of migration depends upon whether the balance is one of emigration or immigration and the nature of the migrants lost or gained.

(2) *Marital condition.*—Mortality in certain countries seems to be more dependent on marital conditions than on sex. This is shown by the following table taken from a paper entitled "Some Researches Concerning the Factors of Mortality," by Lucien March (Journal of the Royal Statistical Society, London, March, 1912):

TABLE 7.—*Showing for the period* 1886-1895, *the number of deaths per* 10,000 *persons according to their marital status in France, Prussia and Sweden.*

——	Males, aged			Females, aged		
	20-39	40-59	60 and over.	20-39	40-59	60 and over.
France:						
Married	77	153	583	80	121	456
Single	103	246	794	78	166	730
Widowed or divorced ..	211	293	1,148	145	198	930
Prussia.						
Married	71	175	582	79	128	497
Single	84	231	806	59	179	729
Widowed or divorced ..	201	346	1,091	101	172	805
Sweden:						
Married	53	114	453	66	96	364
Single	83	204	690	61	120	528
Widowed or divorced ..	104	190	856	98	132	698

(3) *Non-residents—Hospitals and Institutions.*—Frequently a hospital or other institution will be located in one community while its patients or inmates will come largely from other places. The extent to which this is true depends upon the nature or reputation of the hospital or institution. The result may be that the local death-rate will be affected to an appreciable extent by deaths of non-residents in such institutions. In England and Wales this difficulty has been overcome by the allocation of all deaths so far as possible to the locality of usual residence.

(4) *Influence of season.*—As a rule, mild winters and cool summers lower the death-rate, the former especially in the old and the latter in the young, especially in infants, the saving arising chiefly from the drop in deaths from Diarrhœa. There is generally a summer maximum in Diarrhœa and Thrush; in winter, in diseases of the heart, lungs and liver, and in spring, in Small-pox and Pertussis.

(5) *Influence of age.*—This appears marked in certain diseases: Diarrhœa, Erysipelas, Small-pox and Pertussis have a maximum mortality in the first year (Small-pox has a second maximum at age 25). Measles, Scarlet Fever and Diphtheria have their highest death-rates during the first few years of life. Cancer increases from age 25 onward, and Phthisis, which appears to be at a minimum at the 5—10 age period, increases thereafter upto 45.

(6) *Influence of the birth-rate.*—Death-rates are said to be influenced by the birth-rate. If there is a high birth-rate, there must be a large proportion of infants and young children in the population, and as the death-rate in infants is high, the general death-rate of the district must be raised; but, if this high birth-rate be continued over a long-period, then there will be not only a large number of infants but also of young adults in the population of an age at which mortality is usually low; and moreover, one must remember that a high-birth-rate implies the presence in the district of adults at the child-bearing age, and among them also the death-rate is low. The mean age of a population really governs the death-rate, for the lower the mean age of the living, the lower should be the death-rate.

(7) *Influence of occupation.*—Various methods of classification may be adopted, a very useful one being professional, domestic, commercial, agricultural, and unoccupied. Similarly, there are various methods of comparison, *e.g.*, different trades may be compared on the basis of the mean age at death of those engaged; or again, the comparison may be made by the proportion between the numbers engaged in and dying in any occupation expressed as a rate per 1,000. Both these methods fail to take into account the different ages of those engaged in the various trades, and for that reason the best method is that which compares the mortality of those engaged in one occupation of a definite age with the mortality of those engaged in another of the same age.

Now, in all statistics relating to occupational mortality, there are certain sources of error arising chiefly from vagueness, in the census returns, of occupations, or from the fact that those who follow different industries do not always start on equal terms, *e.g.*, in general, a weakling would not become a navy or a blacksmith, but rather take to a trade requiring less strength. On the other hand, a weakly individual may start in an occupation which requires much strength and endurance and finally have to abandon it for a trade less strenuous and so tend to raise the death-rate in the latter.

The causes which render certain trades more or less harmful include bad lighting and ventilation of work-rooms with perhaps over-crowding, long hours and over-work, exposure to extremes of temperature and to vapours and gases and to dust, whether mineral or organic; moreover, certain trades appear to encourage the habit of intemperance. Dr. Tatham in his letter to the Registrar-General, on the mortality in certain occupations in the three years 1900—1902, deals at length with the mortality incident to the chief industries of England. This latter appears as a supplement to the 65th report of the Registrar-General, 1908. Dr. Tatham has selected, as the main working part of life, the age period 25—65 and has prepared a comparative mortality figure for each occupation depending on the rates of mortality at the several age-groups.

The disproportionate effects of work and no occupation are well shown in the following table, which represents the death-rate per 1,000 living of occupied and unoccupied males between 25 and 65 :—

Class of Persons.	25—45 Years.	45—65 Years.
Occupied males	7·84	22·73
Unoccupied males	36·31	57·01

This table shows that between 25 and 45, unoccupied males die four times as fast as occupied, and at the later period of life 45—65, nearly 2½ times as fast. During the last ten years, the mortality of the occupied has declined by 16, which decline has been shared by more or less all industries ; but among the following there has been an increase :— lacemakers, hosiers, copper and tin miners, general shopkeepers and labourers. During the same period the mortality of the unoccupied has increased by ⅛th.

The effects of various occupations on health are shown in various tables, from which one sees that at the head of the list in regard to healthiness of work are the members of the various religious denominations, followed by gardeners, nurserymen and agriculturists in general. At the opposite end of the list are to be found general labourers, tin miners, and inn-keepers with their servants. Medical men have a comparative figure of 950 to 750 of the legal profession and 524 of the clergy.

COMPARATIVE MORTALITY FIGURES, OCCUPIED AND RETIRED MALES, AGE 25—65 :—

Clerical	524	Shoemakers	984
Agriculturists	602	Commercial Travellers ..	988
Schoolmasters	665	Printers	994
Grocers	729	Chemists	999
Coal merchants	731	All Occupied and Retired Males	1,004
Ironmongers	741	Tailors	1,027
Legal	750	Metal workers	1,027
Tanners	774	including—	
Artists, etc.	823	(a) Lead workers ..	1,408
Milk-sellers	832	(b) Zinc workers ..	889
Drapers	845	(c) Copper workers ..	1,090
Millers	890	(d) Brass workers ..	1,154
Bakers	922	(e) Tool file and saw makers	1,315
Domestic servants	927	Hatters	1,137
Stationers	931	Butchers	1,148
Bookbinders	934	Transport service	1,190
Saddlers	945	Hair dressers	1,196
Medicals	952	Musicians	1,261
Tobacconists	962	Publicans	1,808
Lithographers	964		
Fishermen	967		

As to the causes of death, Pulmonary Tuberculosis and Diseases of the Respiratory System taken together account on the average for more than one-third part of the total mortality of men in the main working time of life, and in some industries the proportion is much higher than this. File makers, potters, cutlers, copper and tin miners have from 4 to 10 times the mortality from Phthisis and Respiratory Diseases that obtains amongst agriculturists. Coal, iron and stone miners and carpenters appear to suffer less severely than the above from Pulmonary Diseases. Agriculturists appear to have the same death-rate from Respiratory Diseases in general as from Tubercular Phthisis but the following table gives a list of occupations in which the workers suffer more from Tubercular Phthisis than from respiratory diseases in general.

Workers in Industries.	Phthisis.	Diseases of the Respiratory System.
Agriculturists	85	86
Carpenters	150	126
Bakers	165	162
Carpet manufacturers	180	179
Bricklayer masons	194	183
Rope-cord makers	207	174
Cycle, motor manufacturers	217	164
Tinplate manufacturers	221	189
India-rubber workers	244	183
Brass workers	272	228
Wood turners	271	233
Farriers	316	217
Glass manufacturers	283	268
Chimney sweeps	284	272
Lead miners	324	274
File makers	387	325
Cutlers, scissors makers	533	315
Tin miners	816	741

On the other hand, in the following occupations the workers suffer less from Tubercular Phthisis than from Respiratory Diseases in general, *viz.*, iron-stone miners, coal miners, wool manufacturers, millers, blacksmiths, gaswork

men, stone quarriers, chemical and cotton manufacturers, zinc workers, lead workers, coal heavers, gunsmiths, copper workers, potters and copper miners.

The effects of breathing foul, though not necessarily dusty, air are seen in the following table which gives a list of twenty industries in which the workers appear to suffer injury in various degrees. The table indicates that in 14 industries the workers succumb to Pulmonary disease from twice to three times as fast as do agriculturists generally. It further shows that in 18 out of the 20 industries, the workers die more from Phthisis than from diseases of the lungs other than Phthisis, the excess ranging from 13 per cent. in the case of hatters to 139 per cent. in the case of lithographers.

Workers in Industries.	Phthisis.	Disease of the Respiratory System.
Agriculturists	85	86
Artists and engravers	156	111
Drapers	203	105
Watchmakers	189	127
Commercial clerks	202	121
Saddlers	224	122
Lithographers	261	109
Law Clerks	251	125
Lock and key makers	224	161
Cabinet makers	228	166
Tailors	248	157
Textile dyers	193	218
General shopkeepers	354	308
Shoemakers	271	149
Tobacconists	246	177
Hair dressers	258	172
Printers	300	131
Bookbinders	275	174
Musicians	324	178
Hatters	280	248

EFFECT OF CHRONIC LEAD-POISONING.

The following table, which refers to the occupied males only, shows the mortality due to lead-poisoning in certain trades. Taking the standard mortality as unity, lead workers have a mortality 103 times as great, file makers 57 times,

painters and plumbers 22 times, potters 9 and glass workers 8. With the exception of painters and plumbers, the figures show a considerable decline on those of the previous decade.

This decline is possibly due to the supervision which is exercised on those trades carried out on a large scale, by Factory Inspector, etc., as opposed to trades such as plumbing and painting, where the same trained supervision is not in force.

Workers in Industries.	Comparative mortality figures.	
	1890-91-92.	1900-01-02.
Lead workers	243	103
File makers	87	57
Plumbers and Painters.. ..	22	22
Potters	19	9
Glass workers	13	8
All occupied males	1	1

(8) *Influence of density of population.*—The density of population can be calculated in terms of so many persons to each square mile, or in terms of so many acres occupied by each person in the population. Tables compiled in former years would appear to show that when there are more than 400 persons per square mile, then the death-rate increases with the density, other things being equal, not in direct proportion but as the root $\frac{1}{8}$.

Newsholme, however, has pointed out that there is little or no connection between such density *per se* and a high mortality, and that the true index of density is the number of persons per occupied room. Modern experience in regard to hotels, flats, barracks, etc., has shown that if a proper regard is paid to the sanitary construction and conduct of a building, the influence of the number of persons per acre is practically negligible. Two localities may have the same absolute density of population and yet the death-rates may vary widely, by reason of the fact that one district may be

well planned with wide main streets and open cross streets and the other may consist mostly of closed courts and alleys with no through ventilation, and bad lighting. Of course, given precisely similar conditions in two districts, then naturally the more persons there are per acre, the greater should be the death-rate, if only on account of the increased facilities for the spread of infectious diseases. There must be a limit to the number of houses which can be erected on a given area without causing injury to health, and it has been distinctly shown that, in similar districts, a definite relationship exists between density per acre and the death-rate, but this is due to the fact that, all things being equal density per acre is dependent on the number of persons per room, and that, beyond doubt, exercises a powerful influence on sickness and the death-rate for two reasons: (1) the greater the number of persons per acre, the more are infectious diseases spread and the greater the injury to health from breathing impure air; and (2) a higher proportion of persons per acre implies a greater degree of poverty, with the result that food is liable to be deficient both in quantity and quality; and also intemperance and vice in general add their effects to those produced by over-crowding. In England, as a whole it is found that the percentage of over-crowded tenements is higher among one than two-roomed tenements and much higher in the latter than among three-roomed, falling to a comparatively low point for four-roomed tenements. Dr. Niven has published certain statistics in this connection relating to the City of Manchester.

Rooms in tenement.	Death-rates per 1,000.			
	All Causes.	Zymotic.	Phthisis.	Respiratory Disease in general.
1 ..	32.7	7.4	2.4	7.6
2 ..	21.3	4.5	1.8	4.6
3 ..	13.7	1.9	1.2	2.4
4 ..	11.2	1.0	0.7	2.0

In 1892 the average density in England was about 500 per square mile or 0·8 per acre. In 1931, it was 685 per square mile or 1·07 per acre. In Bombay the average density per acre is 75, and the density varies from 19 per acre in Sion to 636 per acre in Second Nagpada. That density *per se* is not the cause of a high rate is shown by the experience of the huge hotels and flats now seen in many large cities.

(9) *Influence of sex.*—On the whole, the death-rate among women is much less than among men, but the mortality appears to be higher in females from Rheumatism, Erysipelas, Diphtheria, Cancer, Anæmia and Pertussis.

Rates per 1,000 *living ; corrected for age and sex.*

Year.	Males.	Females.
1881–85	20.1	17.5
1886–90	20.0	17.2
1891–95	20.0	17.2
1896–1900	19.1	16.2
1901–1905	17.4	14.6
1906–1910	15.8	13.2
1911–1915	15.1	12.4
1916–1920	15.1	11.9
1921–1925	12.1	9.9
1926..	11.2	9.1
1927..	11.8	9.6
1928..	11.1	8.9
1929..	12.7	10.4
1930..	10.8	8.5
1931..	11.4	9.2

INFANTILE DEATH-RATES.

The infantile mortality is occasionally stated as a proportion per 1,000 of the general population, or again, as a proportion to the total deaths.

The most usual method adopted, however, is that which states it as a proportion of deaths of infants under one year of age to the total number of births registered during the year.

It is obtained by multiplying the actual number of deaths of infants under one year by 1,000 and dividing by the number of births during the year.

In England and Wales in the year 1931, there were 41,939 deaths among infants, giving a death-rate of 66 per 1,000.

Year.	1901-1905.	1906-1910.	1911-1915.	1916-1920.	1921-1925.	1926-1930.	1931.
Death-rate	138	117	110	91	76	68	66

If the records for a long series of years be examined, it will be found that the mortality rates are subject to wide fluctuations and that these are most marked in the 3rd quarter of the year, when epidemic Diarrhœa becomes most prevalent.

This excessive rise has been shown to be associated with a high summer temperature, especially when accompanied by deficient rainfall.

Recent investigations tend to show that there is some association also with the increase in the number of the domestic house-fly.

As a rule, the infant mortality is lowest in a purely agricultural district, and highest in mining centres and large towns associated with large textile works.

Table showing Infantile Mortality in urban and rural groups. England and Wales.

Cause of Death.	Ratio of urban to rural mortality, the latter being taken as 100.			
	Under 3 months.	3—6 months.	6—12 months.	Under 1 year.
All Causes	114	152	1	130
Whooping Cough	72	87	90	85
Diarrhœal Diseases ..	221	263	305	263
Premature births	104	179*	67*	105
Congenital Defects ..	118	119	78	115
Atrophy, Debility and Marasmus	97	129	167	106
Tuberculous Diseases ..	156	166	153	158
Convulsions	109	101	88	104
Bronchitis and Pneumonia.	122	149	150	140

* These rates are of little significance owing to the paucity of the data on which they are founded.

The following table gives the infantile death-rate in Bombay City during the period of 1901-1932 :—

Year.	Rate.	Year.	Rate.	Year.	Rate.
1901.. ..	574.5	1911.. ..	379.8	1921.. ..	*666.7
1902.. ..	542.8	1912.. ..	448.2	1922.. ..	402.7
1903.. ..	532.3	1913.. ..	381.1	1923.. ..	411
1904.. ..	459.2	1914.. ..	385.1	1924.. ..	419
1905.. ..	557.1	1915.. ..	329.2	1925.. ..	356.7
1906.. ..	534.7	1916.. ..	387.8	1926.. ..	389
1907.. ..	423.6	1917.. ..	409.6	1927.. ..	316
1908.. ..	450.1	1918.. ..	*590.3	1928.. ..	311
1909.. ..	404.7	1919.. ..	*652.8	1929.. ..	298
1910.. ..	413.9	1920.. ..	*552.2	1930.. ..	296
				1931.. ..	272
				1932.. ..	218

* Epidemic years.

It is necessary to point out, however, that high as the infantile death-rate is in Bombay, it is not so excessive as the above rates would appear to indicate. This is due to the fact that, although all deaths are accurately known and registered, the same standard of registration does not obtain in respect of births, owing to obvious differences in the sources of information and the secretive habits of the people in regard to births.

The subject of infant mortality has, of late years, greatly attracted the attention of the public health authorities and others interested in the waste of infant life.

In the report for 1910 on the public health of Bombay, great stress was laid on the fact that the figures were fallacious, because the number of infants dying during the year under the age of 1 year, calculated on the number of births registered, was incorrect as many of the infants dying were not registered as born.

In the Annual Report of the Registrar-General, England and Wales, it is seen how the birth-rate is measured and it is necessary to adopt that system to explain the necessary correction in Bombay.

Among the several factors affecting the birth-rate, note must be taken of the changes in the women of conceptive ages in the population and of the changes in the age constitution of the married female population; as also of the custom prevailing in Bombay for pregnant women to leave the City and return with the child 2 or 3 months old.

The crude birth-rate, *i.e.*, the proportion of registered births to the total population at all ages, is sufficient for comparing the birth-rate in a population from year to year in other countries: but in India many corrections must be made.

While in conjunction with the death-rate it generally affords a ready means for gauging the natural increase in a population, in India again this would be a fallacy, as the crude birth-rate is not adapted for comparison over a long series of years, because it takes no account of the effect of the changing constitution of a population in regard to age, sex, condition of marriage, etc. It is desirable, therefore, to make a comparison of birth-rates, based not only on the total population but also on the number of possible mothers.

In order to get at a true statement, it would be necessary to include all those children, who are born out of Bombay, of mothers belonging to the City, and brought to Bombay after birth.

During 1920, 4,172 of such children under one year of age were primarily vaccinated in Bombay, but a large number must have escaped vaccination either by death or postponement. From the vaccination returns it is seen that 57.64 per cent. of the births registered were vaccinated during the year; it may therefore be assumed that 57.64 per cent. of the unregistered children were also vaccinated; the balance of 42.36 having escaped vaccination through one cause or another.

Thus the infantile population in the City during 1920 works out as follows :—

No. of births registered	19,731
,, ,, unregistered (of children vaccinated in Bombay)	4,172
,, ,, unregistered and which escaped vaccination (being 42.36 per cent.)	3,066
Total No. of births	26,969

That this is not over-estimating the figure is borne out by the fact that while in 1907 in England the birth-rate per cent. of females between 15 to 45 years of age was 10·5, in Bombay it was 14·3 and in Glasgow 11·4; while the percentage of child bearing women between the ages of 15 and 45 to the total female population was 77·6 in Bombay, it is 46 in England, while the percentage of married women between the ages of 15 to 20 in Bombay was 76·4 compared with ·7 in England.

The birth-rate stated in terms of the total population (crude birth-rate) must, however, obviously vary with the proportion of females of conceptive ages in the population and with the age-constitution of the married female population. Hence the comparison of birth-rates should be based not only on the total number of population but also on the number of possible mothers.

These variations as revealed by the census of 1931 for India, are shown in the following statement :—

Census year.	Proportion per cent. of women aged 15—45 years in the total population of both sexes and all ages.	Proportion per cent. of married women in female population aged 15—45 years.	Of the married women aged 15-45 years, the proportion per cent. of four groups of ages.				Persons married to 1,000 marriageable persons in the population.	Birth-rate calculated.		
			Aged 15-20 years.	Aged 20-25 years.	Aged 25-35 years.	Aged 35-45 years.		On the number of births registered in the year.	Per 1,000 of total population at all ages.	Per 1,000 of female population aged, 5—45 years.
1911 ..	21.28	76.75	18.25	27.30	39.69	14.75	716.75	1920	20.1	94.62
1921 ..	21.2	79.1	15.47	25.58	42.71	16.24	726.9	1921	16.34	76.7
1931 ..	21.5	81.3	17.05	25.22	43.09	14.64	756.0	1931	23.4	108.7

Besides the factors which influence in common the birth-rate of every community, there are some peculiar to Bombay :—(1) the fairly well-established custom of sending prospective mothers home to their parents where the baby has a better chance of life, so that there is in the City a number of children of mothers belonging to the City but born outside it, and therefore not registered; (2) the omission of parents or relatives to register births, through ignorance or neglect, so that there is a considerable number of children who have escaped registration.

The infant mortality, then, should be calculated on the corrected number of births, which in 1920 would be 26,969 giving an infant mortality of 404·0 per 1,000 of the births compared with 228·3 per 1,000 for the whole of India, which, although very high, is not an unreasonable difference for a large city and is much nearer the truth than when calculated only on the number of births registered during the year.

The inquiries into the causes of death of infants under one year and the mortality due to puerperal disease are continued from year to year in Bombay.

The following statement tabulates the work of the Municipal nurses and midwives in regard to attendance at birth and infant visitations. It is their duty to find out and advise prospective mothers as well as attend on confinements and repeat their visits during and after the lying-in period; to find out, as far as possible, and warn against the pre-natal and post-natal influences adverse to infant life :—

Summary of inquiries and of work of Municipal Nurses and Midwives.	1922.	1923.	1924.	1925.	1926.	1927.	1928.	1929.	1930.	1931.	1932.
Total number of births (including still-born) registered	22,368	22,937	23,659	21,984	22,744	23,465	25,843	26,080	27,342	29,368	30,914
Percentage of Still-birth to the total number of births registered	8.5	8.4	7.7	7.8	7.3	7.5	7.1	7.1	7.4	7.4	6.5
Number verified by Nurses	13,365	14,517	12,601	9,961	9,699	9,831	10,813	10,075	10,320	10,623	9,142
Percentage of number verified to the total..	59.8	63.1	53.3	45.3	42.6	41.9	41.8	38.6	37.7	36.2	29.6
Percentage of confinements unattended ..	6.1	5.7	6.5	5.8	6.5	5.8	5.2	4.0	4.2	4.3	4.8
Percentage of confinements attended by unskilled woman	59.9	51.7	50.9	44.1	37.4	38.2	34.1	35.2	29.1	25.8	27.5
Percentage of confinements attended by qualified Nurses (other than Municipal)..	6.7	7.8	7.2	8.8	10.8	9.4	9.2	9.4	9.4	9.2	10.0
Percentage of confinements attended by Municipal Nurses	9.4	13.3	14.6	14.6	14.4	13.5	12.7	10.8	12.0	11.3	12.4
Percentage of children born in Hospital ..	17.9	21.5	20.8	26.7	30.9	33.1	38.8	40.6	45.3	49.4	46.3
Percentage of children born in healthy condition	71.6	63.9	69.2	71.5	65.9	67.8	69.5	64.6	69.3	68.5	68.1
Percentage of children fed on breast ..	62.0	64.2	73.7	71.9	68.0	73.3	72.3	66.5	71.4	67.7	73.9
Percentage of children dying within 30 days.	11.7	14.1	12.3	13.9	12.3	12.0	10.4	8.6	8.3	7.5	7.3
Percentage of cases where the mothers leave home for work	33.5	28.8	33.5	30.4	35.0	32.8	31.2	30.4	29.9	26.9	26.4

The following table shows the number of births registered in this city during the years 1921 to 1932 and also the various causes of death in infants under one year of age. The percentages of deaths under various diseases shown in the table are calculated on the total number of deaths under 1 year of age :—

—	1921.	1922.	1923.	1924.	1925.	1926.	1927.	1928.	1929.	1930.	1931.	1932.
Number of live births registered ..	19,125	20,452	20,995	21,838	20,268	21,068	21,685	24,017	24,220	25,329	27,204	28,894
Number dying before 4 weeks ..	3,877	3,244	3,308	3,406	2,520	2,936	2,552	2,655	2,475	2,547	2,732	2,538
Number dying between the ages of 1 to 6 months	4,168	2,240	2,350	2,562	2,119	2,258	1,949	2,134	2,128	2,193	2,073	1,621
Number dying between ages of 6 and 12 months	4,706	2,752	2,974	3,188	2,573	3,006	2,356	2,679	2,622	2,766	2,596	2,139
Cause of death, Diarrhœa	981	657	662	674	480	491	333	268	303	350	366	280
,, ,, Convulsions	....	1,086	1,106	1,016	827	670	588	654	662	626	620	422
,, ,, Respiratory Diseases	4,507	2,154	2,388	2,685	2,178	2,644	2,118	2,630	2,523	2,529	2,646	2,217
,, ,, Debility	4,395	3,681	3,767	3,953	3,129	3,703	3,106	3,105	2,779	2,791	2,987	2,685

The practical remedies are :—The provision of lying-in hospitals for the poor and free medical attendance, and the provision of a *nurse* before and after child-birth : the provision of lying-in hospitals will, by giving the mother good food, nursing and skilled attendance, do much towards giving the infant a start in life and enable the mother to provide breast-milk to support the child; (2) the education of the Indian midwives at the hospital and the registration and licensing of these women ; the control over the Indian women who attend the confinements is of the greatest importance, and a hospital such as suggested would do a great deal in the direction of training such women; and it would provide outdoor qualified women free, or at a small fee, who would be able to attend and advise the mother during and after confinement; (3) the introduction of a section of the Act so as to prevent a woman without a certificate and license from attending on a confinement ; only women thus trained should be allowed to attend confinement and all such women licensed and registered; (4) the provisions of Municipal milk depots where women could obtain pure milk at a small cost.

The above are some practical suggestions for the reduction of infant mortality, the reduction of mortality in women during puerperal state and the improvement of the health and physique of the child.

They are all in force in most cities of Europe and America, where the State acknowledges its duty towards the people. A great deal is done by philanthropy and much by State-aided institutions; but much is done, with the result that infant mortality has been greatly reduced.

In the whole of England and Wales the infant mortality rate in 1931 was 66 per 1,000 births, while in some other large towns it was as shown below. It was 218 in Bombay City in 1932 :—

London	88 per 1,000.
Birmingham	70 ,,
Liverpool	94 ,,
Manchester	85 ,,
Sheffield	69 ,,
Leeds	77 ,,

The following table is of interest in comparing the rates obtaining in different parts of the world :—

Countries.	Quinquennial Period.	Infantile Death-rate.
New Zealand	1923–27	40
Australia	1922–26	56
Norway	1919–23	56
Sweden	1922–26	58
Netherlands	1923–27	59
Switzerland	1922–26	62
England and Wales	1923–27	72
United States of America	1921–25	74
Denmark	1921–25	85
Scotland	1922–26	90
France	1922–26	90
Canada	1922–26	98
Belgium	1921–25	100
Germany	1922–26	115
Italy	1920–24	132
Spain	1922–26	138
Austria	1920–24	146
Japan	1922–26	152
Ceylon	1922–26	186
India	1926–30	178

In 1908 a Conference was held in London at which all the principal public health authorities were represented. The Conference was presided over by the Right Hon'ble John Burns, M.P., and the following resolutions were passed :—

1. That the Education Department be urged to add instruction in elementary hygiene, with reference to the dietary and rearing of infants, to their present scheme for systematically training girls in the senior classes in the practice and the principles of personal hygiene and the elements of dietary.

2. That in the opinion of this Conference immediate legislation is required enabling sanitary authorities to establish or support depots for the supply of pure or modified or sterilised milk, and to defray the cost out of the moneys available for public health purposes.

3. That in view of the information submitted, the Conference is of opinion that all still-births should be notified within 48 hours to the Medical Officer of Health of the District in which they occur and that no burial should take place without a medical certificate.

4. That notification of all births be given within forty-eight hours to the Medical Officer of Health of the District in which they occur.

5. That in the opinion of this Conference the question of the insurance of infant lives under twelve months is one demanding serious consideration, and with a view to receiving reliable information, the Government should be asked to grant a Departmental Committee of Inquiry on the whole question.

6. (a) That the period of one month's abstention from factory work away from home now imposed on mothers be extended to at least 3 months, and that on their return to work, evidence must be produced satisfactory to the local authority that proper provision has been made for the care of the child.

   (b) That no employer of labour shall permit a woman advanced in pregnancy to engage in factory labour, unless her ability therefor has been certified to the satisfaction of the local authority.

7. (a) That having regard to the ascertained fact that in centres of industries, where women are largely employed away from their homes, an excessive number of deaths of infants takes place, and that this is contributed to by the improper conditions existing at the houses in which infants are placed out to nurse, it is necessary that the persons by whom and the places into which infants are received, should be under supervision by the local authority.

   (b) That the Infant Life Protection Act be amended to remedy abuses which are not at present provided against.

8. That all preparations offered or sold as food for infants should be certified by a Government Analyst as non-injurious and that each packet should contain its analysis.

9. That the Dairies, Cowsheds and Milkshops Order is defective and that any amendment should extend the definition of disease as applied to animals and should make the provision of regulations by local authorities compulsory. That the scope of the regulations should be extended to cover dirty milk, and should enable local authorities to prohibit the sale of any milk which fails to comply with the conditions of purity agreed upon.

10. That in the opinion of this Conference the appointment of qualified women specially trained in the hygiene of infancy is necessary as an adjunct to public health work.

11. That in the opinion of this Conference the Midwives Act, 1902 should be extended to Scotland and Ireland.

THE MIDWIVES ACT, 1902.

The object of this Act is to provide skilled attention for poor women in child-birth; to reduce to a minimum the accidents in labour which result often in permanent injury to either mother or child, or both; and to abolish a class of

infective conditions known as Puerperal Fever, which with skilled care are entirely preventable.

Section I of the Act prohibits any woman, who is not certified under this Act, from using the title of midwife implying that she is so certified. Provision for the certification of existing midwives is made by section II, the chief one being that anyone who can show that she has been in *bona fide* practice as a midwife for twelve months before the passing of the Act may be certified, provided she makes an application before the 1st April, 1905. Should she omit to make such application, she is not allowed to practise midwifery except under the directions of a qualified medical practitioner after the year 1910. By section X of the Act, every certified midwife is required to notify the local supervising authority, in the month of January each year, if it be her intention to practise within the area of such local authority.

The Central Midwives' Board have made rules for the purpose of regulating and restricting within certain limits the practice of midwives. It is the duty of the local supervising authority to ensure that such rules are complied with, and in detail the work to be done by the local authority is as follows:—

1. To exercise general supervision over all midwives practising within their area, in accordance with the rules made under the Act.
2. To investigate charges of negligence or misconduct on the part of any midwife, and to report the same to the Central Midwives' Board.
3. To suspend any midwife from practising, in accordance with the rules under the Act, if such suspension appears necessary in order to prevent the spread of infection.
4. To report to the said Board the name of any midwife, convicted of an offence, practising in the area of the local sanitary authority.
5. To supply the Secretary of the Board each year with the names and addresses of all midwives who have notified their intention to practise.
6. To report at once to the Board the death, or the change of address of any midwife.
7. To give due notice of the effect of the Act to persons at present using the title of midwife.

CAUSES OPERATING IN BRINGING ABOUT A HIGH INFANTILE MORTALITY.

Many of the factors are common in every locality. For convenience they may be divided into *ante* and *post-natal* causes; but it must be remembered that certain causes operate during both periods of existence *e.g.*, the employment of women both before and after labour, poverty, intemperance, venereal disease and insanitary surroundings, etc.

1. ANTE-NATAL CAUSES.

Dr. J. W. Ballantine has brought into prominence the part played by ante-natal causes, including parental alcoholism, in swelling the infantile mortality rate and also lessening the birth-rate. As pointed out by him, from the third month onward the infant is brought into close relation with its mother. The placenta, amongst other functions, acts as a filter and elements which make up the fœtal tissues such as bone, muscle and blood are transmitted by the placenta from the mother's blood to the fœtus. But it does not follow that the elements pass in the same chemical combinations as those in which they are afterwards found in the fœtus. In the case of maternal Tuberculosis and certain mineral poisons, the placenta also acts as a filter. When, however, the filtering functions break down, then germs, toxins, toxic substances, and sometimes anti-toxins, agglutinins and hœmolysins flow across into the fœtus. When this happens, various effects may be produced. The fœtus may die at once from the action of the poison, or it may develop a disease in a form different from that which is found in the mother, or the pregnancy may end in abortion, or, in the later stages of gestation, in premature birth, and the infant may develop the disease after birth and either die or recover fom it. There is another evil effect that the failure of the filter may have on the infant, *viz.*, the production of malformations, deformities and monstrosities. According to the same writer, there are three ways at least in which ante-natal morbid conditions may influence infantile life and health:—(1) *the production of abortions* which may result from conditions such as Syphilis, Nephritis, Alcoholism, etc. The life lost, it is true, is that of an immature organism but one which, if ante-natal conditions had continued to be normal, would in a few months have been of precisely the same value as that of any full-time infant. In city populations it is stated that one pregnancy in 5 ends in abortion; if this be true, it is at once evident that the prevention of all abortions would increase the birth-rate by 20 per cent. From a statistical point of view it may be true that abortions are not infantile deaths and therefore do not swell the mortality figures, but at the same time it is the loss of a potential infant. (2) *Influence of premature births.* Premature labour tends to increase the infantile death-rate. The infant has a better chance of surviving if it comes from a healthy mother and has been delivered at an earlier date, not because of disease, but in order to get it safely through contracted maternal canals. Premature infants born to diseased mothers are very difficult to save alive, *e.g.*, when the mother has Syphilis, or eclamptic seizures, or chronic Bright's Disease or is an habitual inebriate, or has had placenta prævia or accidental hæmorrhage. The child may die owing to the transference to it from the mother of the germs of her disease, or

again the child may die by reason of its prematurity alone. (3) *Influence of fœtal disease and deformities.* Ante-natal morbid states of the infant tend to increase the infantile death-rate even when they do not cause either abortion or premature labour. The disease or deformity may produce various results, *e.g.*, the health of the fœtus may have been so disturbed as to result in ante-natal death and the birth into the world of a dead fœtus or it may make it impossible for the fœtus to stand the strain of being born, causing it, in other words, to be still-born. Again, the post-natal life of the infant may be very precarious as the result of deformities or disease, *e.g.*, hare-lip and cleft palate, when combined, render feeding a difficult problem; similarly congenital heart disease greatly increases the risk in the event of the development of Bronchitis or Pneumonia, Fœtal Ichthyosis may, after birth, cause pathological alterations in the infant's internal organs which sooner or later result in death; and lastly, any grave state of a mother in her pregnancy, as for instance, retal disease or Hyperemesis, may so interfere with the ante-natal nourishment of the infant in the uterus as to cause it to suffer from what is vaguely termed congenital debility.

2. INFLUENCE OF PARENTAL ALCOHOLISM.

Over-indulgence in alcohol increases sterility, abortions, premature labour, dead births, and the birth of delicate children especially seen in chronic cases. Its influence is due rather to changes in the maternal kidneys and placenta than to any direct influence which the drug has upon the fœtal tissues themselves. There is a sensibly higher death-rate among the infants of the mother whose inebriety was developed at an early period. In not a few of the cases in which a mother gave birth to a deformed child there was evidence of chronic alcoholism.

Appended is a table showing the deaths of children under one year from immaturity per 1000 births, during the period 1921-1930 :—

Cause.	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
Congenital Malformations	3.9	4.2	4.1	4.2	4.6	4.6	4.8	4.9	5.2	5.3
Congenital delibility and Sclerema ..	7.4	6.3	5.7	5.7	5.8	5.3	4.2	3.9	3.9	3.4
Icterus	0.7	0.7	0.7	0.7	0.6	0.5	0.6	0.6	0.6	0.6
Premature Birth ..	19.3	18.7	17.6	18.8	17.6	17.5	18.5	17.7	18.6	17.5
Injury at birth	1.4	1.3	1.4	1.4	1.5	1.5	1.8	1.9	2.1	2.1
Disease of umbilicus ..	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2
Atelectasis	1.6	1.5	1.5	1.6	1.5	1.6	1.6	1.6	1.6	1.6

As stated by Newman it is evident, if infants die within a few days or hours of birth, or, even if dying later, show unmistakable signs of having been unequal to the call of bare physical existence, that there must be something more than external conditions of food and management which is working to their hurt. The explanation is clearly to be found in ante-natal causes.

Ratio of mortality among infants to 1,000 births registered in Bombay City.

Cause.	1901–1905	1906–1910	1911–1915	1916–1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932
Premature Birth	5.3	8.6	9.5	17.0	24.5	21.7	20.3	24.4	19.7	27.9	21.9	19.9	24.0	21.7	25.8	25.4
Debility	178.1	145.0	110.7	140.4	205.2	158.2	159.0	165.2	134.5	148.6	121.3	189.3	90.7	88.4	83.0	67.8
All Causes	530.0	415.6	385.6	517.4	666.7	402.7	411.1	419.3	355.8	389.2	316.2	310.9	298.3	296.3	272.0	218.0

3. Influence of the Employment of Married Women in Factory Labour.

The results of Reid's inquiry into the mortality of children under one year in three classes of towns in Staffordshire are well summarised in the following table :—

Classification according to percentage of married and widowed workers to female population between the ages of 18-50 years.	12% and over.	Under 12% but over 6%	Under 6%
Census population, 1901	132,299	263,868	131,508
Infantile Mortality, 1881-1890	195	165	156
,, ,, 1891-1900	212	175	168
,, ,, 1901-1904	193	156	149

The delegates at the National Conference held in London in 1908 were of opinion, from the facts collected by various authorities, that the period of one month's abstention from work away from home now imposed upon mothers should be extended to at least three months, and that on their return to work evidence must be produced satisfactory to the local authorities that proper provision has been made for the care of the child, and that no employer of labour should permit a woman advanced in pregnancy to engage in factory labour unless her ability therefor has been certified to the satisfaction of the local authority. Reid, who has written much on this subject, found that taking a large number of towns in England, irrespective of geographical position, and classifying them according to the proportion of married women workers in each, the infantile mortality rates varied in direct proportion to the number of such workers. Apart

from the more direct results of mothers neglecting their home duties after their infants are born, there is the effect, which cannot very readily be demonstrated by figures, as regards the viability of children as yet unborn of mothers engaging in other than domestic work up to the time of their confinements.

4. INFLUENCE OF ILLEGITIMACY ON INFANTILE MORTALITY.

The death-rate among illegitimate children is very much greater than is the case with legitimate, as will be seen from the following table extracted from the Registrar-General's Report for 1931.

INFANTILE MORTALITY IN ENGLAND AND WALES 1931—ALL CAUSES.

Age.	England & Wales.		Urban Countries.		Rural Countries.	
	Legitimate.	Illegitimate.	Legitimate.	Illegitimate.	Legitimate.	Illegitimate.
Under 4 weeks	30.51	54.80	30.37	55.18	31.07	53.33
4 weeks to 3 months ..	10.44	19.87	10.93	21.02	8.42	15.51
3 months to 6 months ..	8.99	16.66	9.69	19.23	6.13	10.73
6 months to 9 months ..	7.61	10.68	8.09	11.69	5.68	6.99
9 months to 12 months ..	6.74	8.72	7.20	9.59	4.81	5.45
Total under one year ..	64.29	110.73	66.28	116.68	56.11	92.01

In a subsequent note we find that the excess of illegitimate mortality is greatest from Diarrhœa and wasting diseases and least from the group of common infectious diseases; the first-named cause being that upon which neglect would probably have the most influence, and the last that upon which it would have the least.

A frequent cause of infantile mortality is the ignorance of the mother in regard to the proper method of feeding and clothing a child. Apart from ignorance, there is the question of insanitary houses and surroundings and the difficulties of obtaining a pure milk-supply and retaining it in such a condition until consumed. Probably, largely due to these difficulties and to the inability of the mother to estimate, at their proper value, the plausible advertisements of some of the patent food vendors, many such foods are now given to infants. To meet these conditions, it has been proposed, and in many places actually given effect to, to give a course of instruction in the elementary schools to girls in elementary hygiene, with special reference to the value of perfect cleanliness both of the person and of the surroundings, and in the dietary and clothing of infants; also to establish pure milk depots so as to bring a supply of pure modified or sterilised milk within the reach of mothers who, for one reason or another, are unable to suckle their infants. In regard to patent foods, it is suggested that legislation should be set in motion to compel all preparations offered for sale or sold as foods for infants to be certified by a Government Analyst as non-injurious and that each packet should contain a clear statement of the analysis of its contents.

5. INFLUENCE OF LIFE INSURANCE ON INFANTILE MORTALITY.

Much has been said and written in reference to infantile insurance and there have been several Parliamentary inquiries into the subject. One of the earliest was that of the Select Committee of the House of Commons on the Friendly Societies Bill of 1854, when the Committee reported as follows :—

" Your committee draws this conclusion that the instances of child-" murder, where the motive of the criminal has been to obtain money " from a Burial Society, are so few as to by no means impose upon " Parliament any obligation, for the sake of public morality, to legis-" late specially with the view to the prevention of that crime. No " sufficient grounds exist for the general suspicion which seems to " have been entertained on the subject and this suspicion appears " to have been entirely founded upon the few cases brought to trial, " exaggerated by the horror with which the idea of a crime so heinous " would naturally be regarded."

Writing in 1894, the Chief Registrar of Friendly Societies of England and Wales says : " upon considering the evidence adduced before all these Committees and the Friendly Societies Commissioners, I do not think it has materially altered the conclusion at which the Committee of 1854 arrived at."

By Clauses 62—67 of the Friendly Societies Act of 1896, all Industrial Assurance Companies and Friendly Societies are bound by certain regulations, where by the amount payable on the death of a child under 5 years of age is limited to £6 and, if under ten years, to £10.

That the insurance of infantile life is open to abuse is evidenced by the great caution exercised by some of the leading companies, and the definite rules laid down, among which may be found the following : (1) No child is to be proposed for insurance until 14 days old. If death occurs within three months of the policy being effected, no amount is payable so that no money can be received until a child is 4 months old. (2) Illegitimate children are not to be accepted till three years old. (3) A Superintendent's report is necessary in the case of twins under one year of age.

So notorious has the unsatisfactory business in certain portions of some towns been, that some companies refuse to entertain proposals from residents in those quarters unless the Superintendent has seen the proposer and specially reported upon the situation.

As these are merely departmental rules of certain companies, it is obvious that, in face of the great competition that exists, companies not in the first flight may by slack administration place grave temptations in the way of weak individuals. At the National Conference on Infantile Mortality, London, 1906, it was resolved that in the opinion of the Conference the question of the insurance of infant lives under 12 months is one requiring serious consideration and, with a view to securing reliable information, the Government should be asked to appoint a Department Committee of Inquiry upon the whole subject.

MATERNITY AND INFANT WELFARE.

This is a very vital problem which has been engaging the serious attention of various public and philanthropic bodies and health authorities in India. The figures of maternal and infantile mortality throughout this country

are very unsatisfactory. It is estimated that 22,000 babies are born everyday in India, and nearly 30 out of every 100 of these die before they are a year old, whilst at least 20 per cent. do not survive even the first four weeks of birth. This means that out of the 22,000 babies born daily, 6,600 die whilst no fewer than 138,000 out of the infants born every month of the year do not survive. This indicates an appalling loss of infant life, much of which can be saved by appropriate measures. It is not necessary to go into the details of the causes of this high rate of mortality in this chapter. Suffice it to observe that poverty, ignorance, living in overcrowded and highly insanitary dwellings, venereal diseases, immaturity of mothers, absence of skilled and expert treatment during and after confinement owing to the employment of untrained midwives or *dais*, faulty upbringing of infants owing to the absence from home of mothers who have to be at work from early morning to late at night, and the hard work that mothers are required to do during pregnancy almost up to the period of confinement are some of the most important factors which contribute to this sad state of affairs.

In Bombay City the rate of infant mortality per 1,000 births registered, has been as follows since the year 1925 :—

355.8 in 1925; 389.2 in 1926 ; 316.2 in 1927; 310.9 in 1928 ; 298.3 in 1929 ; 296.3 in 1930 ; 272 in 1931 ; and 218 in 1932. These figures show a welcome and decided decline in the toll of infant life, as compared with the figures recorded between the years 1900 to 1920. The activities of some of the public and philanthropic bodies which are engaged in Maternity and Infant Welfare have largely contributed to this satisfactory result, and below is a short description of their work :—

The Bombay Municipality has engaged qualified Midwives to find out prospective mothers among the poor class population, to attend during confinements and visit the patients for ten days or so, and give advice on the care and feeding of

infants. They give relief to poor women during confinement in the shape of certain necessaries and comforts, such as milk, bread, bed, blanket, charpoy, etc. Homely talks and advice on personal cleanliness, and that of the home and its surroundings are also given.

The Bombay Municipality has established 5 Maternity Homes in different parts of the City for the conduction of normal confinement cases. Ante and post-natal clinics have also been opened in these maternity homes, and classes for the instruction of midwives are also held therein.

The work of the Bombay Municipality has been augmented by the "Bombay Presidency Infant Welfare Society" which has opened nine Welfare Centres in different parts of Bombay, and two Maternity Homes. The aims and objects of the Society are to afford protection to the mothers during the ante-natal, natal, and post-natal periods.

By means of ante-natal clinics it is possible to prevent miscarriages, still-births, and deaths of infants in the very early periods of their existence. Sepsis, eclampsia, anæmia and other forms of illness during pregnancy, if treated in time, can be greatly alleviated by means of these clinics. In fact it is possible by proper ante-natal care, not only to reduce the deaths of unborn infants, and save the life of many infants who are apt to die within a week of birth, but also to improve and preserve the health of the mothers, to save them from prolonged and exhausting labour, and after confinement, to restore them to such a condition of health as will render them capable of performing the duties of motherhood in a fitting manner. Many expectant mothers are naturally not aware of the necessity of seeking timely advice from the doctors in charge of these Centres. According to Kenwood and Kerr an expectant mother should consult a doctor at once under the following circumstances :—

(*a*) If she has any loss of blood.

(*b*) If she suffers from excessive sickness or headache.

(*c*) If she has puffiness of face or swelling of the legs or private parts.

(*d*) If she is not passing the usual quantity of urine.

(*e*) If she has a discharge or sores of any kind.

(*f*) If the bowels do not act daily.

(*g*) If she has varicose veins.

(*h*) If her abdomen is unduly large.

Protection to the mothers during the natal period is given, as mentioned above, by qualified midwives attending on labour cases in the homes of the poor, or advising expectant mothers to resort to maternity homes and hospitals. Owing to ignorance and poverty, the care of mothers during parturition is very much neglected in this country. Confinement takes place in dark, insanitary and ill-ventilated rooms, and the services of a native *dai* who is ignorant of the rudiments of cleanliness, are still in requisition. As a result of the malpractices of these *dais*, deaths of infants from tetanus neonatorum, and of mothers from puerperal fever are not uncommon.

The post-natal period is very important, because the health of both the mother and her infant depends upon the care and attention bestowed during this period. It has an important influence upon the capacity for future child-bearing. The mothers visit the clinics with their infants and are taught how to take care of themselves, and to bring up their children so as to tide the latter over the particularly dangerous first twelve months of life. The periodical weighing of infants at the Centres gives the best indication of their physical progress, and stimulates the mother to take greater interest in the welfare of their off-springs. As most of the ailments of infants are due to improper feeding, the mothers are instructed on the proper methods of nursing babies. If for some reason or other a mother is unable to nurse her baby, she is taught how to hand-feed the child by being instructed in regard to the

quality, quantity, mode of preparation of the food, and the condition of the feeding bottle. Early commencement of household or other work after delivery, and want of proper food and clothing, mostly produce ill-health of the mother.

Under the conditions existing in large cities, many women of the poorer classes have to supplement their family income by seeking employment in factories and workshops. This necessitates their absence from their homes for many hours. For such women a cheap and well-administered crèche, where their children could be looked after, is a great boon.

A crèche has been established by the Infant Welfare Society which is open from 7 a.m. to 6 p.m. daily except on mill-holidays. Children under five are brought there by their mothers while they go to work. There is a qualified nurse, and four *ayahs* to attend to the needs of the children. They are examined by one of the Lady Doctors, twice a week. A kindergarten teacher is employed to teach the children for two hours daily. They are bathed with hot water in the morning and are given clean clothes to wear, which are taken off when they go home. They are then given canjee, chapatty and butter in the morning; rice, dhal, and vegetables at noon; and cocoa and butter biscuits in the afternoon. The infants are fed on milk diet and those women who are working close to the crèche, come and nurse their babies at regular intervals. In the afternoons, they go to sleep, and on waking up are given toys to play with. Thus they are very well looked after and made to observe clean habits. Twice every year they are given an outing to some selected places outside the City. Sun-light treatment does them good. One great blessing of a crèche of this description is, that it serves to prevent the drugging of children with opium, which is unfortunately a common habit with mothers who do so in order to keep them quiet at home while they go to work. In order to

eradicate this evil habit of administering opium to infants and children, which is one of the causes of sending them to an early grave, the Society educates mothers on the ill effects of the drug by means of cinema shows and magic lantern lectures. Every large factory ought to have such a crèche.

An Anti-Venereal Clinic is conducted by the Infant Welfare Society once a week and is a very important preventive measure as many miscarriages, still-births, cases of opthalmia neonatorum, congenital syphilis and many other evils of venereal diseases are prevented by treating infected expectant mothers with appropriate anti-venereal remedies. This treatment also serves to reduce puerperal sepsis.

The Committees of the National Baby and Health Week organise every year in the principal cities in India magic lantern lectures, demonstrations, cinema shows relating to maternity and child welfare work.

The untrained midwife or *dai* being one of the most important factors contributing to the high rate of infant mortality, lectures were organised by the Bombay Sanitary Association to instruct them how to deal with normal cases of pregnancy.

The Lady Wilson Village Maternity Association has been formed for providing facilities for training centres to teach the elements of midwifery to native *dais* in the Bombay Presidency. It does not pretend to train the *dai* in midwifery in all its details. The sole object aimed at is to improve the existing methods employed by the village *dais* in labour cases. For this purpose arrangements are made to bring these *dais* to a large Centre for about a fortnight or so, and give them there opportunities to see about a dozen confinement cases in an up-to-date hospital. The main ideas impressed on their minds are, the necessity of thoroughly washing their hands before attending on a confinement case, boiling their scissors before using them, and above all learning the secret of non-interference and avoiding what is known as "meddlesome midwifery", and allowing nature to do her own work in her own time. They are also taught how to perform artificial respiration in an asphyxiated newly born infant. Finally they are given a lecture in which all the

main points of the course are simply and intelligently recapitulated, and illustrated by means of diagrams. After this course is completed, each *dai* is given a certificate and supplied with a simple outfit consisting of an aluminium pot with cover which serves as a receptacle to keep the set in, and also as a vessel in which the scissors can be sterilized, roll of umbilical tape, a pair of detachable scissors, and a soap box with a cake of antiseptic soap.

The practice of midwifery by nurses, midwives, and *dais* requires to be controlled and supervised in the interests of the mother and the child. The Government of Bombay, therefore, intend passing a "Nurses' Registration Act" with the object of maintaining an official Register of Nurses, Midwives and *Dais* and having disciplinary powers over the persons so registered.

Registration of births has long been regarded by Medical Officers in England as opening up great possibilities of hygienic work in the interest of the mother and infant. Notification has been, therefore, made compulsory and the Medical Officer of Health must be notified *within thirty-six hours of every birth*, after the twenty-eighth week of pregnancy whether the child is alive or dead. In Bombay, births have to be notified to the Executive Health Officer within seven days after their occurrence.

The employment of mothers in industrial occupations shortly before and after the birth also affects infantile mortality. A Maternity Benefit Act passed in 1929 for the Bombay Presidency gives adequate rest to the mother before and after confinement, as she is entitled to three months' leave in all, of which the period after confinement must not exceed 42 days.

ZYMOTIC DEATH-RATES.

The term 'zymotic' is applied to the seven principal infectious diseases *viz.*, Small-pox, Measles, Scarlet Fever, Diphtheria, Pertussis, Diarrhœa, and Fever (which term includes Typhoid, Typhus and simple continued Fever).

There are various methods of calculating the rate, *e.g.*, (1) As a proportion of deaths to persons attacked; this method is useful in determining the virulence of an outbreak

and also in deducing the effects of treatment but it is open to objection for purposes of comparison as the two groups compared may have a different age and sex distribution. and zymotic diseases are known to vary in fatality according to age and sex. (2) The rate may be stated as a proportion to the deaths from all causes. (3) The deaths from each particular zymotic disease may be stated as a proportion per 1,000 of the population; or, (4) the deaths from each particular disease at a given age-period may be stated as a proportion per 1,000 of the population living at that particular age-period. The third method is that, adopted by the Registrar-General and thus, like the birth and death-rates, the zymotic rate is calculated on the estimated population of the district, *e.g.*, Population 20,000, deaths 40, then the rate is $\frac{40 \times 1{,}000}{20{,}000} = 2{\cdot}0$.

Mortality per 1,000 living from certain Epidemic Diseases :—

Countries.	Years.	Epidemic diseases.				
		Measles.	Scarlet Fever.	Diphtheria.	Enteric Fever.	Whooping Cough.
England and Wales ..	1927	0·09	0·015	0·070	0·008	0·094
	1928	0·11	0·015	0·081	0·009	0·075
	1929	0·08	0·018	0·087	0·008	0·160
Austria	1927	0·05	0·02	0·07	0·03	0·10
	1928	0·04	0·01	0·07	0·03	0·07
Germany	1927	0·06	0·02	0·04	0·02	0·07
	1928	0·04	0·03	0·05	0·02	0·06
France	1927	0·05	0·014	0·050	0·048	0·041
	1928	0·06	0·012	0·058	0·055	0·055
Belgium	1927	0·086	0·015	0·032	0·028	0·109
	1928	0·081	0·014	0·037	0·028	0·107
Denmark	1927	0·08	0·003	0·05	0·008	0·09
	1928	0·08	0·006	0·06	0·006	0·08
	1929	0·01	0·004	0·03	0·007	0·04
Norway	1926	0·003	0·001	0·026	0·009	0·047
	1927	0·019	0·004	0·020	0·015	0·050
	1928	0·020	0·009	0·015	0·006	0·055
Switzerland	1927	0·017	0·008	0·039	0·019	0·050
	1928	0·058	0·009	0·052	0·014	0·053
	1929	0·012	0·009	0·050	0·011	0·025
	1930	0·009	0·008	0·055	0·007	0·032
Australia	1927	0·02	0·03	0·06	0·03	0·06
	1928	0·03	0·02	0·07	0·03	0·04
	1929	0·02	0·02	0·07	0·02	0·05
New Zealand	1928	0·009	0·040	0·052	0·012	0·019
	1929	0·001	0·019	0·065	0·016	0·012
Japan	1927	0·22	0·00	0·08	0·013	0·15
	1928	0·18	0·00	0·07	0·014	0·18

In the decade 1881-1890 the zymotic rate in England and Wales was 2·34 per 1,000. Of later years it has shown a tendency to fall; in 1894 it was 1.76 per 1,000. At no time can the rate be taken as quite accurate, as deaths due to protracted sequelæ of acute infectious diseases are sometimes credited to the secondary cause and not to the true primary one, *e.g.*, Bronchitis and Pneumonia may be given as the primary cause of death and the fact that they may have followed on Measles or Pertussis is not stated.

It will be seen that, as far as England and Wales are concerned, there has been a fall in mortality from Measles, Scarlet Fever, Enteric and Pertussis since the period 1881-1885. The death-rate from Diphtheria has, however, remained more or less unaltered.

The statistics for Bombay City are given in the following table. Rates per 1,000 :—

Year.	1895.	1905.	1915.	1925.	1928.	1929.	1930.	1931.
Diarrhœa ..	1·44	3·09	0·59	*1·43	*0·6	*0·7	*0·8	*0·8
Small-pox ..	0.32	2·78	0·36	0·45	0·4	0·9	1·3	0·0
Measles ..	0·66	0·79	0·07	0·12	0·1	0·0	0·1	0·0
Plague ..	*Nil.*	18·29	0·61	0·13	0·2	0·0	0·0	0·0
Enteric ..	0·04	0·07	0·11	0·12	0·1	0·2	0·2	0·1

* Includes Enteritis.

Age and sex both appear to exert an influence on the mortality from zymotic diseases. Diarrhœa, Erysipelas and Small-pox have a maximum mortality in the first year of life, Measles in the second, Scarlet Fever in the third and Diptheria in the fourth. As regards sex, the mortality is greatest in females in Erysipelas, Diptheria and Pertussis.

Crude annual death-rates, England and Wales, from the principal Epidemic Diseases. Mortality per million living :—

Year.	Measles.	Small-pox.	Scarlet Fever.	Diph-theria.	Per-tussis.	Typhus.	Typhoid.	Diar-rhœa.
1901 ..	276	10	133	273	313	1	155	926
1902 ..	392	75	148	236	297	2	126	429
1903 ..	274	23	125	182	285	2	100	554
1904 ..	363	15	111	170	352	1	93	879
1905 ..	324	4	112	160	255	1	89	601
1906 ..	273	1	101	177	241	..	92	886
1907 ..	361	..	92	164	293	1	67	305
1908 ..	228	..	80	158	280	..	75	517
1909 ..	356	1	91	148	203	..	60	284
1910 ..	232	1	66	120	246	..	53	203
1911 ..	363	1	52	135	217	..	67	919
1912 ..	352	..	55	118	230	..	44	142
1913 ..	291	..	57	121	149	..	41	424
1914 ..	217	..	77	158	218	..	46	359
1915 ..	462	..	66	165	230	..	35	299
1916 ..	155	..	39	154	176	..	30	199
1917 ..	308	..	22	132	134	..	28	181
1918 ..	289	..	29	142	296	..	26	163
1919 ..	96	1	33	133	71	..	16	122
1920 ..	191	1	38	150	117	..	14	118
1921 ..	59	..	34	126	121	..	16	451
1922 ..	149	1	36	107	167	..	12	191
1923 ..	138	..	26	71	108	..	12	218
1924 ..	125	..	23	65	103	..	13	193
1925 ..	137	..	25	71	156	..	10	214
1926 ..	89	..	17	77	105	..	9	215
1927 ..	92	1	15	70	94	..	9	158
1928 ..	109	1	15	81	75	..	11	164
1929 ..	86	1	18	87	160	..	9	178
1930 ..	105	1	19	88	51	..	7	138
1931 ..	62	..	14	67	63	..	5	131

THE PHTHISIS DEATH-RATE.

A high Phthisis death-rate in a city or a division thereof may be due to defective conditions of housing or of workshops in which the people are employed. These defects may take the form of dampness of sites, bad construction and drainage, bad lighting and ventilation, or overcrowding. Again, certain trades by the very nature of the processes carried out predispose the operative to this disease. In addition poverty, drunkenness and ignorance largely assist in maintaining a high death-rate in a district already affected so also do certain customs, *e.g.*, the observance of strict *purdah* in the case of Mahomedan women must be held to be at least partly responsible for the very high death-rate from Phthisis in such. The influence of milk drawn from cows suffering from tubercular disease of the udder must not be overlooked, and there is now a considerable tendency towards the belief that many cases of adult Tuberculosis are but a recrudescence of tubercle acquired in early childhood from infected milk.

The following table gives the mortality per 1,000 living from Pulmonary Tuberculosis, in 14 principal towns in India, for the year 1929 :—

Town.	Death-rate from Tuberculosis.	Town.	Death-rate from Tuberculosis.
Belgaum	3.51	Surat	2.69
Poona	3.45	Calcutta	2.4
Ahmedabad	3.44	Rangoon	2.33
Darjeeling	3.00	Howra	1.30
Lucknow	2.96	Bombay City ..	1.26
Karachi	2.86	Nainital	1.19
Agra	2.82	Dacca	0.8

In Bombay City the mortality is as under for the years 1901-1932 :—

1900—9.07	1905—3.29	1910—2.23	1915—1.44	1920—1.66	1927—1.3
1901—8.39	1906—3.64	1911—2.12	1916—1.42	1921—1.37	1928—1.3
1902—5.09	1907—2.94	1912—2.22	1917—1.47	1922—1.22	1929—1.2
1903—3.66	1908—2.44	1913—1.86	1918—1.62	1923—1.12	1930—1.1
1904—3.82	1909—2.46	1914—1.55	1919—1.85	1924—1.26	1931—1.3
				1925—1.11	1932—1.2
				1926—1.37	....

The death-rate per 1,000 for all ages in England and Wales has declined and this decline is greater at nearly all ages in females than in males (except between 5-15).

The age of maximum mortality has been postponed in both sexes, due both to (*a*) a saving of life at ages most liable formerly and (*b*) a postponement of death in those attacked.

CLASSIFICATION OF STATISTICAL DATA.

Data obtained by the various methods described are grouped or classified under various headings. For example so far as the duties of the Medical Officer of Health are concerned, the births are classified according to sex, and the deaths according to sex, age and diseases. In large urban districts the system of classification usually adopted is that of the Registrar-General, but for small urban or rural districts the limited tabular returns required by the Local Government Board will be sufficient. In either case, however, printed forms should be used for classification and arranged to contain all the data for weeks, months or quarters.

In classifying data of any kind, it is essential that the individual units should have precise and definite characters, so that every unit in a group should be strictly included in that group. Then again, the dividing character of every group should be so distinct and clearly defined as to afford no room for doubt under which group of heading every unit should be classified. Care should also be taken that no unit should be classified so as to apear in two allied groups at the same time. Thus, we shall suppose that a death has been returned as due to Phthisis as the primary and Diarrhœa as the secondary cause; it would obviously vitiate the results if the single case were classified under the heading of Diarrhœa, and also under that of Phthisis.

It is most important that this rule should be strictly observed. Now, in practice, certain difficulties arise when two diseases are entered on the death certificate, and in neither case is the duration of the disease mentioned. Doubt naturally arises as to the disease to which death is to be attributed for statistical purposes. To meet this difficulty, certain general rules have been drafted so as to secure uniformity of data.

GENERAL RULES.

(1) *Constitutional Diseases* come before any other except Zymotic, so that Phthisis comes before any Respiratory Disease in whatever order they may be in the certificate.

(2) *Circulatory Diseases* take precedence of Urinary,

e.g., Heart Disease, Nephritis, } classify as Heart Disease,

(3) *Urinary Diseases* take precedence of Respiratory,

e.g., Bronchitis, Nephritis, } classify as Nephritis.

(4) *Influenza.*

If any disease of longer duration be given, then classify as that, *e.g.*—

Influenza 2 days, Pneumonia 8, = Pneumonia.

But Influenza 6 days, Pneumonia 2, = Influenza.

If no duration is given, then classify under the first-named.

(5) It is very desirable that medical practitioners should use in their certificates of death only those terms which are recognised by the Royal College of Physicians, London. The cause of death should be stated precisely and briefly, English names for diseases being used in preference to their equivalents in other languages.

(6) Vague terms, such as decline, consumption, tabes, cachexia, etc., should be avoided, and hæmorrhage should not be signed as a cause of death without an indication of its origin and probable cause. So also Dropsy should not be given without particulars as to probable origin, *e.g.*, in some disease or other of the heart, liver or kidneys.

(7) In certifying death from Small-pox, the patient's condition with respect to vaccination should be most carefully stated, *e.g.*, (1) no evidence of any vaccination; or (2) vaccinated in infancy, only stating the number and size of scars combined; or (3) vaccinated only after exposure to small-pox the incubation period of which is nearly always twelve days; (4) stated to have been vaccinated but no scars visible.

Always state the size of the scars when combined in terms of fractions of a square inch.

Various Examples.

Icterus Neonatorum, classify as Liver Disease.
Bronchitis, Apoplexy, classify as Apoplexy.
Heart Disease, Child-birth, classify as Heart Disease.
Phthisis, Child-birth, classify as Phthisis.

Pregnancy, Uræmia, classify as Uræmia.
Pregnancy, Pneumonia, classify as Pneumonia.
Child-birth, Pneumonia, classify as Pneumonia.
Abortion, Sepsis, classify as Puerperal Sepsis.
Abortion, Hæmorrhage, classify as Abortion.
Paralysis, classify as Hemiplegia.
Chronic Bronchitis, Acute Pneumonia, classify as Bronchitis.
Spinal Diseases, classify as Diseases of Organs of Locomotion.
Tabes Mesenterica, Pneumonia, classify as Tabes.
Scarlet fever, Child-birth, classify as Scarlet fever.
Rickets, Pneumonia, classify as Rickets.
Enteric, Influenza, classify as Enteric.
Emphysema, Bronchitis, classify as Emphysema.
Acute Eczema, Pneumonia (in an infant), classify as Eczema.
Cardiac Asthma, classify as Heart Disease.
Pneumonia, Laryngitis, classify as Pneumonia.
Morbus Cordis, Alcoholism, classify as Alcoholism.
Heart Disease, Asthma, classify as Heart Disease.
Measles, Diphtheria, then class under disease of longer duration. If no duration given, then first-named.
Brights's Disease, Apoplexy, classify as Brights' disease.
Diarrhœa, Pneumonia, classify as Pneumonia.
Diarrhœa, Bronchitis, classify as Bronchitis.

STATISTICAL EVIDENCE OF THE HEALTH OF COMMUNITIES.

Estimates of the general health of a community are usually based on a consideration of the following :—

(*i*) General death-rate.
(*ii*) Zymotic death-rate.
(*iii*) Infantile death-rate.
(*iv*) Phthisis death-rate.
(*v*) Mean age at death.
(*vi*) Probable duration of life.
(*vii*) Expectation of life.

(*i*) *The general death-rate,* **especially if corrected for age and sex, is a fairly good criterion. It is liable to be misleading where the population is small, and if not corrected for sex and age. Another source of error is the uncertainty of the population towards the end of an intercensal period; further, especially if the population is small, the death-rate is liable to great fluctuations by reason of the occurrence of epidemics which have no known relation to sanitation.**

(*ii*) *The Zymotic death-rate* is really a somewhat uncertain guide. A high death-rate from certain zymotics, *e.g.*, Diphtheria, Enteric, Typhus and Diarrhœa may imply a defective sanitary condition. Typhus almost certainly does, but on the other hand, some of these may be due to purely temporary causes arising outside the town altogether, *e.g.*, infected milk and water or oysters or uncooked vegetables. Further, Small-pox, Measles, Whooping Cough and Scarlet Fever do not, as a rule, appear to be influenced by defective sanitary conditions. It must not also be overlooked that deaths due to protracted sequelæ of acute specific diseases (zymotics) are frequently erroneously credited to secondary and not the true primary cause, *e.g.*, Bronchitis and Pneumonia following on Whooping Cough and Measles.

The prevalence of Zymotic Diseases varies according to the number of susceptible children in the population and this fact must also be taken into consideration.

(*iii*) *The infantile mortality* is by some regarded as a reliable test of the sanitation of a place, as migration does not affect the result much, but (it is often observed that) the infantile death-rate is high in towns with a low general death-rate. The rate is influenced by so many factors, that it cannot be considered a very safe index. Whooping Cough, Measles, prematurity, ignorance and want of care on the part of the mother combined with, in many instances, practically compulsory absence of the mother at work all day in the fields or factory, all influence the infantile mortality. So also does parental alcoholism. Yet these causes cannot be said to directly reflect the insanitary condition of a town. On the other hand, epidemic Diarrhœa, which is a very fatal disease of infancy, does imply defective sanitation.

In appraising the value of the infantile death-rate as a criterion, one must analyse the cause of the mortality.

(*iv*) *The Phthisis death-rate*—A high dea h-rate from Phthisis is generally indicative of defective sanitation in dwelling houses, workshops, public buildings and places of public resort, combined with ignorance and poverty. These two latter play a much greater part than they have been credited with in the past.

The influence of modern methods of travel in trains and tramcars on the spread of the disease must not be lost sight of.

Meat and milk of infected animals also play a part.

(*v*) *The mean age at death* is obtained by adding up the ages of all those who have died, and dividing by the number of deaths. As a criterion it is of little value, as it is influenced by the infantile mortality, which, if excessive, lowers the mean age at death, and it is also influenced by the age and sex distribution of the population.

(*vi*) *The probable duration of life* is the age at which exactly half of any given number of children will have died. It can only be obtained from a life table and is of no very great value.

(*vii*) *The expectation of life* **at any age is the average number of years which a person of that age may be expected to live.**

The expectation of life at birth is known as the mean duration of life, whereas the expectation of life at all other ages than birth is known also as the mean after life-time.

The expectation of life is obtained from a life table and is the true measure of the vitality of a community.

In the absence of a life table, **we can calculate the expectation of life for any age between 25 and 75 by the formula of Willich.**

Let x=Expectation of life, a=Present age, then $x=\frac{2}{3}(80-a)$;

Or, by Farr's method from the birth and death-rates—

$$\text{Expectation of life at birth} = \frac{2,000}{3D} = \frac{1,000}{3B}$$

METHOD OF DEATH REGISTRATION IN BOMBAY CITY.

Bombay City is divided into seven Wards (A to G); the seven Wards are divided into ten districts, Wards B, C and E having two district offices each on account of their size and density of population. Each district (I to X) has an office which is in charge of a District Registrar and is used for the record of births and deaths in the district, and also as a free public dispensary for the poor.

Working under each Registrar of Births and Deaths are two Sub-Registrars, qualified Hospital Assistants or Sub-Assistant Surgeons and a qualified midwife and under these Sub-Registrars are death registration ramoshis.

The duties of these ramoshis are to exercise a vigilant outlook for all funeral parties passing through their division and, when encountered, to approach the leader and ascertain certain particulars which must be entered on the annexed form which is in triplicate.

The form is printed in the vernaculars and in English.

The information it conveys may be seen from the specimen copy.

No.........................

MEMO. OF DEATH.

मृत्यूची नोंद.

This is to certify that the information regarding the
दाखला देण्यांत येतो कीं खालील मयतासंबंधी

deceased herein named is correct.
खबर बरोबर आहे.

Name ....

नांव ____

Sex ....

पुरुष किंवा स्त्री ____

Age ....

वय ____

Caste ....

जात ____

Date and hour of Death..

मयत झाल्याची तारीख व वेळ ____

Place of Residence :—

राहण्याचें ठिकाण ____

(*a*) House ....

(अ) घर ____

74

(*b*) Street ....

(ब) रस्ता——————————

(*c*) Ward ....

(क) वार्ड——————————

....

Death Registration Ramoshi No...................*Distt. No*........................

मृत्यूची नोंद करणार रामोसी नं०—————डिस्ट्रिक्ट नं०—————

One copy is given to the relatives, one to the District Registrar and the third is retained by the ramoshi. The District Registrar (or Sub-Registrar), on receipt of this information, visits the deceased's house and ascertains the history of illness from the relatives or from friends, or he may perhaps obtain a death certificate from a medical man, or, in the event of having received information of the death before disposal of the corpse has taken place, he may be able to obtain a certificate from the medical man or may view the body.

It must be particularly noted that the slip given by the ramoshi is in no way a death *certificate*; it merely records certain statements as to age and more particularly the address which the ramoshi must verify.

The verification of the alleged cause of death lies with the District Registrar, after consulting the relátives and interviewing the medical attendant.

In regard to those bodies which reach the cemetery without a ramoshi's pass, the cemetery clerk, makes certain enquiries from the relatives and forwards the answers to the District Registrar early next morning.

The District Registrar proceeds to the house as before and endeavours to ascertain the cause of death.

In the event of the cemetery clerk being suspicious in regard to any body brought for disposal, he is empowered to refuse permission to dispose of or remove the corpse until he has communicated with the Police.

REPORT OF DEATH IN THE CITY AND ISLAND OF BOMBAY.

Serial No. ....

Date of Death ....

Abode:
- District ....
- Sub-District ....
- Ward No. of House ....
- Street or Wadi ....
- No. of house in Street or Wadi ....

Duration of residence in Bombay.
- Years ....
- Months ....
- Days ....

If a stranger to Bombay or lately arrived, where from ....
- Village ....
- Taluka ....
- District ....

Name (and surname if any) ....

Sex ....

Race, caste or nationality ....

Age ..
- Years ....
- Months ....
- Days ....
- Hours ....
- Still-born ....

Occupation or profession of Deceased or Family ....

Place of Birth
- If in Bombay ..
  - District ....
  - Street or Wadi ....
  - No. of house ....
- If out of Bombay
  - Village ....
  - Taluka ....
  - District ....

Country to which family belongs ....

Cause of death ....

Duration of Disease .. ..
- Years ....
- Months ....
- Days ....
- Hours ....

Name of the Medical Attendant..

Residence of Medical Attendant..

Place of Disposal of Dead, No. { Buried.......................... / Burnt .... / Exposed ....

Date of Information given : } ....

....192 . } Signature of Informant.

District Registrar's Register No..

....

Registrar No: District.

REGISTRATION OF BIRTHS AND DEATHS.

An accurate registration of births and deaths is as important as an accurate estimation of the population collected at the census. Sanitary improvements depend very largely on the value of this information.

In England, the Births and Deaths Registration Act of 1874 requires every birth to be registered within 42 days of its occurrence and every death within 5 days thereof.

NOTIFICATION OF BIRTHS ACT, ENGLAND, 1907.

(1) In the case of every child born after the 1st day of January 1908, it shall be the duty of the father of the child, if he is actually residing in the house where the birth takes place at the time of its occurrence, or in his absence, of any person in attendance upon the mother at the time of the birth or within six hours thereafter, to send or give notice of the birth to the Medical Officer of the district in which the child is born within 48 hours after such birth.

(2) It shall be sufficient compliance with this section if notice be sent by prepaid letter or post card addressed to the Medical Officer.

(3) It shall be the duty of all the rural and urban Sanitary Authorities to bring the provisions of this Act to the attention of all medical practitioners and midwives, practising in their districts.

(4) Any person who fails to give or send notice of a birth in accordance with this section shall be guilty of an offence and shall be liable on summary conviction to a penalty not exceeding 20 shillings.

(5) The notification required to be made under this Act shall be in addition to and not in substitution for the requirements of any Act relating to the registration of births.

(6) This section shall apply to still-born children as well as to children born alive.

CITY OF BOMBAY ACT III OF 1888 AS MODIFIED UP TO 1920.

Section 442.—For the purpose of registering births and deaths, the Commissioner shall divide the city into such and so many districts and sub-districts as he shall from time to time think fit and a municipal officer shall be Registrar of births and deaths of each such district.

443. (1) Every Registrar shall reside within the district of which he is Registrar and shall cause his name together with the words "Registrar of births and deaths for the district of . . ." to be affixed in some conspicuous place at or near the outer door of his place of abode; and (2) a list showing the name and place of abode of every Registrar in the city shall be kept at the municipal office and shall be open at all reasonable times to public inspection free of charge.

444. The Commissioner shall provide and supply to the Registrar a sufficient number of register books of births and of register books of deaths for the registration of the particulars specified in the Schedules N and O respectively, and the pages of each of the said books shall be numbered progressively from the beginning to the end thereof.

Schedule N.—Particulars to be specified in the register of births are serial number, date of birth, place of birth showing district, sub-district ward No. of house, street or *wadi*, No. of house in the street or *wadi*, names (and surnames, if any,) of parents, their occupation or profession and place of birth and duration of residence in Bombay in years, months and days; whether the mother is the only wife alive at the time of the birth or one of two wives both being alive, or one of three or more wives, all of them being alive : whether the mother was married or unmarried, whether the child was born alive or still-born, its sex, race, caste or nationality, and name (if any), the signature of the informant and the date of information given.

Schedule O.—Particulars to be specified in the register of deaths are serial number, date of death, abode showing district, sub-district, ward No. of the house, street or *wadi* number of the house in the street or *wadi*; duration of residence in Bombay in years, months and days, if a stranger to Bombay or lately arrived, where from, giving village, taluka, district; name and surname if any, sex, race, caste or nationality, age in years, months and days or still-born; occupation or profession of deceased or of his or her family; place of birth, if in Bombay, giving district, street or *wadi* and the number of the house; if out of Bombay, the village, taluka and district, country to which family belongs, cause of deaths, duration

of disease in years, months, days and hours; name and residence of the medical attendant; place of disposal of the dead giving number of cemetery and whether buried, burnt or exposed.

Section 445. (1) Each Registrar shall inform himself carefully of every birth and death, which shall happen in his district and of the particulars concerning the same required to be registered according to the forms in the said schedules and shall, as soon after such birth or death as conveniently may be, register the same in a book supplied for this purpose by the Commissioner, without making any charge or demanding or receiving any fee or reward for so doing other than his remuneration as a municipal officer. (2) Other municipal officers, besides the Registrars, may be appointed with the duty of informing themselves of every birth or of every death in the district to which they are respectively appointed and of the particulars concerning the same required to be registered and of submitting such information to the Registrar of the said district or to such other person as the Commissioner directs.

446. (1) It shall be the duty of the father and mother of every child born in the city and, in default of the father and mother, of the occupier of the premises in which to his knowledge the child is born and of each person present at the birth and of the person having charge of the child, to give to the best of his knowledge and belief to the Registrar or other municipal officer appointed under section 445, within seven days after such birth, information of the particulars required to be registered concerning such birth; (2) provided that in the case of an illegitimate child no person shall as father of such child be required to give information under this Act concerning the birth of such child and the Registrar shall not enter in the register the name of any person as father of such child, unless at the joint request of the mother and of the person acknowledging himself to be father of such child, and such person shall in such case sign the register together with the mother.

447. In case any new born child is found exposed, it shall be the duty of any person finding the same, and of any person in whose charge such child may be placed to give, to the best of his knowledge and belief, to the Registrar or other municipal officer aforesaid, within seven days after the finding of such child, such information of the particulars required to be registered concerning the birth of such child as the informant possesses.

448. (1) For every place for the disposal of the dead registered in the register kept under section 435, a municipal officer shall be appointed whose duty it shall be to receive information of the particulars required to be registered concerning the death of every person whose corpse is disposed of at such place; and (2) if the Commissioner shall not think fit to require the municipal officer so appointed to be in constant attendance at any place for the disposal of the dead for which he is so appointed, there shall be affixed to a conspicuous part of the entrance to such place a notice, specifying the name of the officer so appointed for the said place and the place where he may be found.

449. (1) It shall be the duty of the nearest relative of any person dying in the city present at the death, or in attendance during the last illness, of the deceased and, in default of such relatives, of each person present at the death, and of the occupier of the premises in which to his knowledge the death took place and, in default of the persons hereinbefore in this section mentioned, of each inmate of such premises, and of the undertaker or other person causing the corpse of the deceased person to be disposed of, to give, to the best of his knowledge and belief, to the officer appointed under the last preceding section, information of the particulars required to be registered concerning such death; and (2) the said information shall be given at or about the time that the corpse of the deceased person is disposed of, and it shall be given in writing if the informant can write, and otherwise orally, and the informant shall make known to the officer aforesaid his name, designation and place of abode, and shall attest the correctness of the information which he gives, to the best of his knowledge and belief, by his signature or mark.

450. (1) In the case of a person who has been attended in his last illness by a duly qualified medical practitioner, that practitioner shall sign and forward to the Commissioner a certificate of the cause of such person's death in the form of Schedule P, or in such other form as shall from time to time be prescribed by the Commissioner in this behalf, and the cause of death as stated in such certificate shall be entered in the register together with the name of the certifying medical practitioner.

(2) The Commissioner shall provide printed forms of the said certificates and any duly qualified medical practitioner resident in the city shall be supplied, on application, with such forms, free of charge.

Schedule P.—Certificate of Cause of Death. I do hereby certify that I attended the deceased..........................during his last illness and that the cause of his death was, to the best of my belief.......................(here state particulars). Dated.......................Signed.......................Medical designation or Diploma..

451. (1) The information concerning deaths received by every officer appointed under section 448 shall be entered by him in a register-sheet which shall contain the particulars contained in Schedule O, and shall be forwarded, at such intervals as shall be prescribed by the Commissioner, through the Registrar of the district to the municipal office; and (2) from the said register-sheets and from the certificates furnished to him under section 450, the Commissioner shall cause the register book of deaths to be prepared and shall have prepared and published such tabular returns and statements as shall appear to him to be useful for sanitary or other purposes.

452. (1) Any clerical error which may at any time be discovered in a register of births or in a register of deaths may be corrected by any person authorised by the Commissioner in that behalf. (2) Any error of fact or substance in any such register may be corrected by any person authorised as aforesaid by entry in the margin, without any alteration of the original entry upon production to the Commissioner, by the person requiring such

alteration or error to be corrected, of a declaration on oath setting forth the nature of the error and the true facts of the case, made before a Magistrate by two credible persons having knowledge of the case.

In connection with the registration of births, the chief facts usually required are the sex, date and place of birth, the number of children, legitimacy or otherwise, and the residence, nationality or caste of the parents.

The following form illustrates the method in which a report of birth in the City and Island of Bombay has to be made :—

REPORT OF BIRTH IN THE CITY AND ISLAND OF BOMBAY.

Serial Number....................................

Place of Birth.	District	
	Sub-District	
	Ward No. of House	
	Street or Wadi	
	No. of House in Street or Wadi	
Parents	Names (and surnames, if any)	
	Occupation or Profession	
	Place of Birth	
	Duration of residence in Bombay	Years ....
		Months .....
		Days ....
Mother being.	Only wife now alive	
	One of two wives, both now alive	
	One of three or more wives, all now alive	
Mother being	married / unmarried	
Child	Born alive	
	Still born	
	Sex	
	Race, Caste or Nationality	
	Name, if any	

Remarks—

Signature of Witness. Signature of Informant.

Date of information given :

Bombay,..19

District Registrar's Register No...

District Registrar's Signature.

NOTE.—In the case of the birth of a Hindu, the particular sub-division of caste should be given. Christians should be separated into those of pure European parentage; those of mixed blood, *viz.*, Indo-Europeans ; and those of pure Asiatic parentage, *viz.* Indian-Christians. Negro-Africans or Siddis should be registered as such, and not as Mussalmans. In the case of Europeans their religion should be specified.

In Bombay City notification of births is compulsory but in order to afford every facility to the general public to record such occurrences, there are working under each District Registrar of Births and Deaths, Sub-Registrar and birth *karkoons.* Each Registrar's district is equally divided, and it is the duty of these *karkoons* to make a house to house visitation in their district and ascertain if any births have occurred during the week, and any information so obtained is reported to the District Registrar who himself, or through his assistants, obtains the full details as required in the specimen form given above.

Dr. C. A. Bentley in a paper read before the second All-India Sanitary Conference, Madras (1911), described the system of registration of vital occurrences in Eastern Bengal as follows : the system is typical of what it is elsewhere except in Presidency towns where it is regulated by law :—

"As is customary in India, the village *chowkidar* is responsible for reporting vital occurrences in Eastern Bengal. The beat of each *chowkidar* includes from 75 to 100 houses or *baris.* There is a *duffadar* over every 30 *chowkidars,* and the President of the *chowkidari* unions also exercises some control over them.

"The *chowkidars* are supposed to visit every house in their beat at intervals : once a week, or once a fortnight in the case of outlying districts, they attend the *chowkidari* parade at the *thana* police station ; and they give in their reports of vital occurrences on this occasion.

"The pay received by *chowkidars* is so low that they are obliged to add to their income in other ways, and they usually hold and cultivate land. It is also not an uncommon occurrence to find a *chowkidar* whose own house is in a village some miles from his legitimate beat Under these

circumstances there is no certainty of the men visiting the different portions of their beats with any regularity; and in many cases they appear to rely upon gaining their knowledge of births and deaths by inquiry among the villagers who attend the weekly *bazars*. As it is an exception for a *chowkidar* to be literate, the entries in their *hath-chittas* are usually made by the *duffadar or panchayat* or in some cases at the *thana* police station itself. Many of the men too are comparatively aged and have impaired memories for recent events. Some *chowkidars* have been met with who were unable to remember if a birth or death occurred in their beat during the preceding week, fortnight or month. This being so, there is little chance of the returns of vital occurrences being accurate. During the investigation, it was found that omissions on the part of the *chowkidars* to record births numbered about 6 per cent. of the whole, and about 4 per cent. of deaths were not recorded. These figures, however, give false impression, because at the beginning of the inquiry a much larger proportion of omissions was detected. But later on the *chowkidars* became much more careful in their reporting and many deaths and births which they had at first failed to note were subsequently recorded by them, sometimes a very long time after they had occurred.

"There are other grounds also for believing that ordinarily a much larger percentage of omissions occurs in the registration of the births and deaths. The more ignorant and superstitious among the villagers have a great dread of reporting the occurrence of a birth, as they fear that their doing so may lead to the death of the child; and they will often actually deny that a birth has occurred, especially when a death has recently taken place among the family. The analysis of the age-periods at which deaths occur shows that frequently almost as many deaths are recorded among children aged 1-5 years among infants. These facts suggest the possibility of many births and deaths of young infants going unreported.

"As regards the classification of the causes of death, the investigation shows that in the district examined the only returns of any value are those relating to Cholera and Small-pox. The heading "Fever," as is well known, is absolutely misleading and about as useful as that of "all other causes". But this is not entirely the fault of the village *chowkidar*. His own reports are frequently much more informing than those that eventually filter through to the authorities; and with a little trouble might be made exceedingly valuable. There are commonly understood terms for many easily recognised diseases current among the villagers in every district; and until driven into the routine method of reporting deaths as due to "Fever", "Cholera", or "Small-pox", the *chowkidars* make frequent use of them. Sudden deaths are often reported as "*thabra*" or "*thapti mara*," literally "a sudden blow"; Tetanus Resnatorium as *pachoa paoa*, literally attacked by a ghost; and Measles, Phthisis and Pneumonia are often indicated by special names, such as *bappi*, *koki*, and *bath sleshwar*. But when the *daroga* or writer constable at the *thana police* station receives such reports, they usually go down in his register under the heading "other causes" merely because such terms are not used in the schedule.

" Observations made during the course of investigation appear to show that it would be possible to improve the existing system of registration without great difficulty. Under the existing system all vital occurrences are pooled at the *thana* police station and the Civil Surgeon or other district officials cannot get detailed information without special inquiry; even then, it is not an easy matter to get accurate figures for the various unions, and it is still more difficult to get figures for individual villages.

" But if a register were kept in which each union in a thana was given an initial A. B. C., etc., and each chowkidari beat in the union was assigned a number A-1, A-2, A-3, etc., and all the entries were recorded by beats and unions, it would be possible to immediately locate pecularities in the returns, especially high or excessively low mortalities. As the number of houses in each beat are known, it would be a very simple matter to gauge from this register the approximate mortality rate of every portion of a thana.

" By collecting for each district the current names in common use for a number of diseases, inserting them in the vernacular schedules, and giving special instructions that the chowkidars should be ordered to report all deaths from these causes, it would be possible also to greatly increase the value of the present returns. It is possible, however, that a scheme for keeping special registers in each union, utilizing the services of the panchayats, village patwaris (where they exist) or village school-masters for the purpose might give good results. Village school-masters are particularly well placed for obtaining information regarding vital occurrences independently of the reports of chowkidars, so that they could easily exercise a check upon the registration of vital occurrences; and in connection with the attempt to teach elementary hygiene in the schools, it might be a useful measure to interest them in such matters.

" Finally, the importance of more careful registration of the total number of deaths occurring must be strongly emphasized. Each year sees an increasing demand for an extension of measures of sanitation but, in the absence of accurate recording of vital occurrences, there is a grave danger that, instead of finding improved sanitation result in a diminished death-rate, we shall actually see an apparent increase of mortality taking place. In the case of Municipalities in Eastern Bengal, death registration is a mere farce. In Chittagong town, an investigation in 1911 showed that 35 per cent. of the deaths went unrecorded; and in Dinajpur town in 1912, inquiry has shown that 40 per cent. of the deaths occurring during the first six months were not reported. In the face of the facts, it would appear that improved registration both for urban and rural communities is the most urgent of all sanitary reforms."

CHAPTER XVII.

Routine Work of the Sanitary Official.

In the chapter on 'Administration' the duties of the sanitary official in a large city in India have been laid down in detail.

The work of the sanitary officer, whether he be the Executive Health Officer of a large city, an Assistant or Deputy, or whether he fills the post of Sanitary or Conservancy Inspector, varies largely from that of a sanitary official in England.

The Health Officer in England and in India.

In England the primary duties of the Medical Officer of Health are those concerned with the investigation and control of the spread of infectious disease. His work is purely advisory, and in no sense is he an Executive Officer as in India. He has to systematically inspect his district and be prepared to advise his authority on any matter affecting the public health. In many districts of England and Scotland, the Health* Officer and the Sanitary Inspector have distinct duties to perform and each reports separately to his authority or committee, but subject to the instructions of that authority, the Health Officer may superintend the work of that Sanitary Inspector. He has certain duties to perform with regard to food and milk supply and offensive trades, and has from time to time to make reports on various matters which in his opinion may affect the public health, and the action taken by him or on his advice with regard to offensive trades, dairies, cow-sheds, milk-shops, factories and workshops, &c., school medical inspection and Tuberculosis. He must also compile and report on the vital statistics of his district. His sphere of work is, no doubt, wide.

but owing to the stringency of the by-laws, the pressure of public opinion and the desire on the part of the public of a Western city to have their surroundings in a sanitary condition, the work of a Health Officer in the West is more cut and dried, more defined and less liable to misconstruction and obstruction than that of his confrere in the East. Modern developments in sanitary science in the West have compelled the Medical Officer of Health to become more and more a specialist and to search for scientific and interesting work; but in India, while opportunities for special investigation and interesting work come daily to hand, he has rarely time to specialise, as he must be intimately in touch with the whole organisation of his department, which embraces multifarious duties unheard of in English cities.

The duties of the Health Officer of a city in India with a large population, include the supervision of the conservancy and sanitary work and control of a large staff of subordinates and labourers, the registration of births and deaths and the inquiry into the cause of every death, the responsible work of investigating the cause of diseases, inquiring into complaints from the public, and advising on plans of sanitary requirements of buildings. The carrying out of the duties set forth require that such an officer should be a highly trained and well educated man with experience in public health administration, gained by previous responsible work in England and India, which will give him the confidence of the authorities and of the people; the salary must therefore be sufficiently high to attract the class of men with the qualifications above indicated.

The conditions of climate, habits and customs and religious susceptibilities of an enormous moving population, following different faiths, add to the difficulty of carrying on the administration of his Department.

In England the Health Officer does not supervise the conservancy work, has no labour to control, and is not the

Registrar of Births and Deaths, nor has he the cause of death of every person to be inquired into by the Health Department. Shortly, then, the work of the Health Department in Indian cities comprises the ordinary public health work of a Health Officer in England and in addition the whole of the conservancy work of the city and the control of the labour staff, the regulation of trades, and the registration of births and deaths and the inquiring into the cause of every death and all outbreaks of Plague, Cholera, Malaria, Small-pox, etc.

It is advisable in the interests of Indian cities that the conservancy work should be done by the Health Department, as it is intimately connected with its sanitary administration, and it is essential that a high standard of work should be aimed at : this can only be done by employing the right class of men to assist the Health Officer.

A Health Officer must possess an extensive and accurate knowledge of all matters pertaining to public health, and he should take advantage of every opportunity for examining personally the practical details of all questions that arise. The knowledge thus gained by actual inspection and practical experience, will serve him in good stead when dealing with problems that daily occur ; mere theoretical information gained from books is liable to lead him into difficulties.

Nothing should be taken for granted, and second-hand information should rarely be relied on. He will meet with questions requiring much tact and discretion. Private and public interest often clash. Pressure may be brought to bear on him by interested parties, and he may find himself in trouble unless he brings forward accurate information backed up by a straightforward and conscientious intention to do the right thing.

A great deal depends on the personality of the Health Officer. He must remember that he is dealing with those who consider they have, but do not really possess, that knowledge of technical subjects in which the Health Officer is an expert.

Discretion and tact are attributes that come naturally, and are difficult to acquire if not natural. In bringing forward questions of great importance to public health, he will often find himself opposed by conflicting opinions, interests who will put obstruction and difficulties in his way; he may be defeated temporarily, but he must not give in and while bending to an adverse decision he should wait for a favourable opportunity to bring forward his suggestions again and again.

The Health Officer will have to meet in committee members of his council to consider questions relating to the public health of his district and he should be able to control his temper. Members of council consider themselves to a certain extent privileged to make statements that they would not dare to utter in their private capacity as citizens. A sense of fairness and justice to an official as a rule, on the part of some of the members, will defend him against what may be uncalled for and unfair attacks. He will listen patiently to all argument and opinion, but he must have a firm guiding hand.

Most men prefer to be led rather than driven and the Health Officer must gain the confidence of the public and his sanitary authority, without which he will not be successful. He must not be in too great a hurry to push forward improvements or innovations, however keen he may be to see good results. Things "hurry slowly" in the East, and municipal government in any country can never be accused of haste.

A Health Officer must keep before him a high standard; zeal in his work, careful consideration of his subject, remembering the conditions of life surrounding it in the East, will soon convince his authority that he can be relied on.

In order, therefore, for a Health Officer to properly perform his duties, he must have an intimate acquaintance with all the statutes, acts and by-laws relating to his office;

he should be thoroughly conversant with the principles of modern sewerage, drainage, disposal of sewage, water supply, ventilation of buildings and house construction and practically acquainted with the duties of the Inspector of Nuisances, and the methods of conservancy system. He should have a knowledge of trades, articles of trades and manufacturing processes that are likely to be controlled by the Corporation. He must be thoroughly acquainted with the etiology of diseases, with the appearance and symptoms of all infectious and tropical diseases, and must know the principles of hospital construction and administration. He must have a knowledge of bacteriology and parasitology and chemistry, although he will not have time for much research work. He must have a knowledge of vital statistics and be able to compile statistics, and to deduce sound conclusions therefrom. He must have a knowledge of the methods of analyses of water, air and foods, although not always called upon to perform these analyses; he should understand meteorology, climatology and kindred subjects.

He must be a good organiser and administrator and have an enormous capacity for literary work and writing numerous reports, which will be expected of him. In addition to these qualifications, he must be possessed of tact, discretion and good judgment, patience and perseverance, and must be courteous and impartial in all his actions. These latter attributes are especially necessary in dealing with the population of India.

In his visits of inspection to houses, stables, factories, workshops, or premises, wherever his duty may call him, he must conduct himself with discretion and tact. Persuasion and good address are valuable adjuncts to the sanitary official; he should by these means gain the confindence of the public, and although invested with important powers it is not always necessary to push them to the limits. Honesty, sobriety and straightforwardness, combined with good

temper and knowledge of his work, will soon gain for him a reputation for reliability, without which he will be a failure. He will frequently meet with opposition and intrigues, temptation, false information and anonymous attacks against his character. Accusations of bribery and corruption are common. These can only be overcome by having the confidence of his superior officers and the public, and their support.

CONSERVANCY INSPECTORS.

In India the work of the Conservancy Inspector and Sanitary Inspector may be combined or separate. In the case of the former official, his duties are chiefly to supervise labour staff, the cleansing of streets, privies, latrines and the removal of refuse. In India this is no light task, as on it depends the cleanly appearance of the city and to a very large extent the health of the people. It has already been pointed out that this work should be done by the Health Department as, if it is placed under the Engineering Department, the dual control is likely to lead to inefficiency and friction with a resulting effect on the health conditions of the city.

In the chapter on the Administration of Public Health Acts, the subject of duties of officials has been gone into in detail. The way these duties are carried out must depend largely on local circumstances and surroundings and the financial aspect. The great and persistent object to be kept in view is supervision, *systematic, strict and everlasting,* without which no subordinate officials or labour staff can be kept up to their work.

The Conservancy Inspector will have to face difficulties with his labour staff; strikes, corruption, bribery and false information in connection with the food supply of the bullocks, stores, coal, oil, etc., and complaints from the public. He must be a strong man mentally and physically, for he will have many difficulties to contend with.

ROUTINE WORK OF SANITARY INSPECTORS AND THE WORKING OF THE SANITARY PROVISIONS OF THE CITY OF BOMBAY MUNICIPAL ACT.

The actual methods of work of a Sanitary Inspector in different places will differ in degree only, varying with the size and importance of the towns and the powers given him under the local Acts and the financial position of the Municipalities. In England the duties of the Sanitary Inspector are rigidly laid down, and in the larger cities and presidency towns of India some such instructions and methods of work should be followed. In the City of Bombay the following is the procedure adopted.

During the daily morning and afternoon rounds entry is effected by the Sanitary Inspector into or upon a building or land, (under the powers delegated to him under section 488 of the Act) and a regular inspection (under section 374) is made of premises to ascertain the sanitary condition thereof.

INSPECTION OF PREMISES.

While inspecting the premises, first of all an inspection of the surroundings and outside of the building for human habitation is made, and notes are taken on the following points :—

(a) The width of the road and the surrounding open spaces.

Any action, if necessary, is taken by the Engineering Department.

(b) The height of the building.

Any action, if necessary, is taken by the Engineering Department.

(c) The condition of the open spaces, gullies and sweepers' passages.

If the open space comprises vacant land in a filthy condition, action against its owner is taken under section 377 to clean it. If the gullies are found in a dirty condition, the Conservancy Inspector concerned is requested in writing to have them cleaned and flushed.

If the pavement of a gully is broken, action under section 257 to have it repaired is taken by the Health Department, and if heavy repairs are needed or a gully is *kutcha* and requires remodelling, the Drainage Department is requested by letter to have proper repairs executed, pavement made, or the gully remodelled.

When a house-drain is found choked, the attention of the House-Drain Inspector is at once drawn either by telephone or in writing to relieve the choke, and he in his turn, if he finds that the choke in the house-drain is due to a choke in the street connection, at once requests the Drainage Department to relieve the choke in the street connection.

(*d*) Whether there is any ditch, pool of water, quarry-hole, tank, well or low land in which the storm or waste water stagnates, action under section 381 is taken by the Health Department to fill up such ditches, tanks, pools, etc.

(*e*) The condition of the sanitary fittings fixed on the outside of the external walls. If the sanitary fittings are found, on inspection under section 253 and 256, to be out of order or broken, action under section 257 is taken by the Health Department to repair, renew or lengthen such waste-water or discharge pipes, cistern-heads or, cleaning caps, etc.

If any of the waste-water pipes or a gully trap on any premises is found choked by the Sanitary Inspector, the Conservancy Inspector concerned is requested by telephone or in writing to get such waste-water pipes cleaned and choke removed from the gully traps, provided the choke is accessible by means of an ordinary ladder, otherwise action is taken under section 257.

(*f*) The plinth of the house.

(*g*) The condition of the flooring, size and partition walls of the room and the materials of which they are made.

(*h*) The means of light and ventilation of rooms.

(*i*) Internal open space or *chowks.*

(*j*) The area of each room and the number of inmates thereof.

If the plinth is found low, *i.e.*, less than two feet above the level of the road, the flooring is made of earth or is damp and not paved with stone slabs or impervious materials, if the walls are of split bamboos plasterd over with mud and dung, or of wooden planks or are damp; if the roof

is low and of inflammable materials, the rooms dark and ill-ventilated owing to the means of light and ventilation being insufficient, or defective: if the floor area of the room is less than 100 square feet and the cubic capacity less than 1,000 cubic feet, such a house is considered insanitary and unfit for human habitation, and is reported to the Standing Committee with a request under section 378 to declare the house unfit for human habitation, and in the event of its being found overcrowded, action under section 379A is taken by the Health Department.

(*k*) The soundness or stability or otherwise of the building. If the house is observed to be in a dilapidated or ruinous condition, it is at once reported to the Engineering Department for necessary action under section 354 of the Act. Houses which are abandoned or unoccupied are similarly reported to the Engineering Department for action under section 376.

(*l*) Water supply from a well or from a Municipal main; the position of the tap and the pipes. If the position of the water tap is found near the privy or other objectionable place, or the tap is found out of order, or the service pipe is laid in the open channel drain or in contact with sewage, or any direct water connection is found with the flush tanks in the water-closets or inside the privies, the Water Department is requested by letter to take necessary action under section 273-A of the Act for its removal from the objectionable position.

(*m*) Whether or not there is a well inside the house. Sample of well water is sent for analysis. If the well is found foul, or requires to be cleaned, action under section 381 is taken by the Health Department or, if the well requires to be closed or covered, a reference is made to the Malaria Branch of the Health Department to take action under the same section.

(*n*) The situation of bathrooms or *nahanis* and their drainage arrangements.

If the bathrooms or *nahanis* are found not properly drained or trapped, a letter is written to the Drainage Department to take necessary action in the matter. If they are found insufficient, action under section 248 (1) is taken by the Health Department.

(*o*) Sanitary conveniences. Whether the house is served with a basket privy or a privy on the intermediate water carriage system, or a water-closet on the full flushing system. Number of seats, their condition, sufficiency or otherwise, whether properly detached or not, whether dark or ill-ventilated and whether properly drained and trapped.

If on inspection (under sections 253 and 256) a privy or a water-closet is found in a dilapidated and broken condition, the seats being broken and the beds of the traps below the surface level of the drain, or the drainage is defective or is not in good order or condition, action is taken, under section 257, by the Health Department.

If it is dark and not well ventilated, action under the same section is taken by the Health Department to ventilate the same. If the beds and seats are broken and if there is no proper receptacle in the trap of a privy on basket system, action is taken under the same section of the Act for the necessary repairs and the provision of a receptacle. If in case of a water-closet on the full flushing system, the apparatus and appliances require repairs and to be put in working order, action is taken under section 257 by the Health Department; if the privy accommodation is found insufficient, *i.e.*, if it be not in the required proportion of one seat to a set of every five rooms—action for such additional number of seats required is taken under section 248 (1) (*a*). If structural or other alterations in the existing water-closet, privy or urinal accommodation are found necessary, action under clause (*b*) of the same section is taken. If a privy on basket system is found on sanitary grounds objectionable, action for converting it into a water-closet is taken under clause (*c*) of the same section of the Act. If a privy on basket system is found not properly detached as per section 250 (1) (*a*) and it is attached to the main building, action under section 249-A (*b*) is taken to detach it, or to close it up to provide in lieu thereof a water-closet on the full flushing system under clause (*a*) of the same section. If a privy on basket system is found exposed to the view of persons living in the neighbourhood or passers by, action is taken under section 250 (*b*) of the Act. If any action as regards detachment, ventilation, flushing apparatus and other appliances in respect of a water-closet is found necessary, action is taken under section 251 to remove the defects. If a privy or water-closet is found to have been built directly over or directly under any room or part of a building other than another privy or water-closet or a bathroom or a terrace, action under section 251-A (*a*) is taken to close the privy or water-closet or under section 378 to render the living room unfit for human habitation. No new privy or water-closet is allowed under section 251-A (*b*) of the Act within a distance of 20 feet from any well, spring, tank or stream liable to pollution, and if any

such privy or water-closet is found, action under section 381 is taken by the Health Department to fill up such well, tank, etc. Action is also taken under section 372 (*f*), where the water-closet pans or receptacles are found to be in such a state for want of flushing as to be offensive or injurious to health.

(*p*) Whether any animals such as goats, cows, bullocks, etc., are kept inside the house. If any are found in a house, action is taken against the owner or owners of such animals under section 384 (*b*) of the Act by the Health Department or under section 384-A.

(*q*) Any case of sickness or birth noted. If any case is met with, it is at once brought to the notice of the District Registrar concerned.

(*r*) If houses, privies, water-closets, etc., are found in a dirty condition and walls smoke-begrimed, or any case of or death from an infectious disease occurs in a house, action under section 375 for the lime-washing of such buildings is taken by the Health Department.

(*s*) Action under section 377 is taken by the Health Department against the owner of open land overgrown with rank and noisome vegetation or on which refuse or *cutchra* is found. Persons caught while throwing *cutchra*, etc., on public roads are prosecuted by the Health Department under section 372 (*e*).

If a *dhobi ghat*, or a place for washing clothes by washermen in the exercise of their calling, is found to be established without the sanction of the Municipal Commissioner, or without carrying out the requirements demanded by the Health Department, action under section 397 (1) of the Act is taken by the Health Department.

Any animals found tethered in a street or a public road are handed over as stray animals, under section 316 of the Municipal Act, to the nearest Policeman, who removes them to the cattle-pond.

For want of proper and suitable housing accommodation for the poor and low class people, such as Wagrees, Mahars, Kathiawadees, etc., a number of them have to accommodate themselves in huts and sheds built of inflammable materials on any available piece of open land in any street. These structures are all insanitary and unfit for human habitation. Action under section 380 of the Act to remove these huts and sheds is taken.

The License Department, taking action under section 394 (*c*) of the Act, at the instance of the Health Department, indirectly compels the owner to remove the sheds that are erected on open land for stabling bullocks, horses or buffaloes, if these sheds have not been licensed for the purpose.

MILCH CATTLE,* HORSE AND BULLOCK STABLES.

Any person who intends to build any of these stables has to make a written application to the Health Department. Such application is to be accompanied by a block plan in duplicate, showing the site of the proposed stable and its surroundings, the drainage arrangements proposed, and other necessary details. In reporting upon the application, the Sanitary Inspector notes on the following three points, as in the case of applications for the establishment of factories, etc., *viz.*, (1) the suitability of the site proposed; (2) whether the locality is open or thickly populated, and whether or not it will prove a nuisance; (3) the distance from the public road and from the nearest dwelling house. If the site is approved and the proposals made are found in accordance with the by-laws, as regards open spaces around the shades, length, width and height of the sheds, pavement of the surface, drainage arrangements, washing place for animals, dung receptacle, place for storing hay and the feed of animals, quarters and privy accommodation for *gowlis*, syces, cart-drivers, etc., the Health Officer (or his Assistant), after visiting the place, recommends the granting of the application, on condition that the requirements suggested by the Health Department are carried out.

Licensed and unlicensed milch-cattle, horse and bullock stables.—If, on inspection of the licensed stables, any of them is found overcrowded, or any repairs to the flooring of the stalls, or to the washing place or dung receptacle or pavement are found necessary, action is undertaken under

* The Bombay Municipal Corporation have laid down in their Resolution No. 4135 of 29th April 1925 that no new milch cattle stables will be permitted in future in Bombay.

section 394, for infringement of the license conditions. If a stable is found in a dirty condition for want of regular removal of dung or stable refuse, action under section 372 (*f*) is taken by the Health Department against the owner or the licensee, as the case may be.

BAKE-HOUSES AND AERATED WATER FACTORIES.

Bake-houses are licensed, under section 394, on their complying with the requirements demanded by the Health Department. If a bake-house is conducted without carrying out the Health Department requirements, the License Department is requested to take the necessary action; the same is done in respect of aerated water factories. For the lime-washing of bake-houses, aerated water factories, public eating-houses, theatres, etc., action is taken by the Health Department under section 375 of the Act.

EATING-HOUSES, TEA AND COFFEE SHOPS, ETC.

Eating-houses, tea and coffee shops are under the control of the Municipality and are licensed under section 394.

Action in respect of a milk-shop is taken by the Health Department. Samples of milk are regularly sent for analysis and the milk-sellers are advised as to the necessity of keeping milk cans and other vessels in a clean condition, and not to expose the milk but keep it in a can having a proper air-tight cover. Milk shops are licensed under section 412A.

Action under sections 414 and 416 is taken by Sanitary Inspectors in destroying meat, fish, vegetable or other article of a perishable nature, which may be found diseased, unsound or unwholesome for human food or for medicine as the case may be.

Samples of articles of food, such as flour, oil, tea, coffee, aerated waters, butter, vinegar, alcoholic beverages, drugs, soaps, etc., are purchased and sent to the Municipal Analyst for analysis.

Prosecution under the Prevention of Adulteration Act of 1925 is undertaken by the Health Department when a sample of butter or ghee analysed is found adulterated.

PUBLIC LATRINES AND URINALS.

An inspection is regularly made and action taken to keep these conveniences clean.

ERECTION OF DWELLING HOUSES, WATER-CLOSETS, &c.

Every person, who intends to newly erect a building, or to re-erect any building pulled down to the plinth, or any frame building of which only the framework is left down to the plinth, or to convert into a dwelling house any building not originally constructed for human habitation, or to convert into more than one dwelling house a building originally constructed as one dwelling house only, has to give, under section 337, notice of his said intention in a prescribed form, as per section 344, to the Municipal City Engineer and to submit, under section 338, a block plan in duplicate showing the position of such building in relation to the adjoining properties, the width and level of the street in front or at the rear, the intended line of drainage, the sites and positions of the proposed privy or water-closet and washing places, means of ingress and egress and light and ventilation, etc. Such a plan should be prepared by a licensed architect and surveyor, under section 339 of the Municipal Act. One of the two copies of such plans is then sent by the Engineering Department to the Drainage Department for remarks as regards the drainage arrangements proposed, and the other copy to the Health Department for remarks as to the site or sites of the proposed privy, cesspool or washing place, and on other sanitary points. The Sanitary Inspector on receiving the plan, finds out the building site from the block plan and then proceeds to inspect the sites of the proposed privy, cesspool and washing place, and their number, under sections 246A and 247 of the Act.

If the sites or site proposed for a privy or cesspool or a washing place be found objectionable on account of its or their being close or directly opposite to a living room or a dining or cook-room of the adjoining house or houses, or near the windows of a bed-room of other houses adjoining, or abutting on a public street or a passage, such site or sites is or are altered and marked by the Sanitary Inspector on the plan. While returning the plans to the Engineering Department, the Health Department draws its attention to the site or sites so altered in the plan and specified the number of privy seats required and the kind and type of the privy or water-closet that should be built. The Engineering Department has to return the plan duly approved or disapproved to the party within 30 days, after which the party commences the building work, in accordance with the provisions of section 348 of the Act and the Building by-laws. The Sanitary Inspector goes every month or fortnight to watch the progress of the building work and to see whether or not the requirements demanded by the Health Department are being carried out during the construction of the building. When the building is completed, the Engineering Department accepts the completion certificate from the party's supervising Engineer if the Health Department has no objection. If any of the requirements, demanded by the Health Department at the time of passing the plans, are found not to have been carried out, then the grant of such a certificate is not recommended, and the Engineering Department takes action against the party under section 353 or 353A, for not carrying out the work according to law, and for occupying the building without permission.

Every person who intends (*a*) to make any addition to a building or (*b*) to make any alterations or repairs to a building not being a frame-building, or (*c*) to make any alterations or repairs to a frame-building, or (*d*) to remove or reconstruct any portion of the building abutting on a street which stands within the regular line of such street has to give to the

Municipal Engineering Department notice under section 342 in a prescribed printed form (under section 344), specifying therein the position of the building in which such work is to be executed, the nature and extent of the intended work and the name of the person who will supervise its execution. If any notice given under section 342 does not supply all the information which the Executive Engineer deems necessary to enable him to deal satisfactorily with the case, he, within 30 days after receipt of the said notice, asks the party concerned to furnish a plan of the building and of the intended new work. On the party submitting such a plan, the same procedure is followed as described in the preceding paragraph.

If a plan is submitted by a party to the Engineering Department for a building for human habitation or a factory, intended to be erected in a cemetery or a grave-yard no longer in use, the Health Department has, under clause (c) of section 348 of the Act, to be satisfied before the foundation of any such building is constructed that all the excrementitious matter or the carcasses of dead animals and other filthy or offensive matter have been properly removed to the satisfaction of the Health Department.

ESTABLISHMENT OF FACTORIES.

Every person who desires to establish any factory, such as a flour-mill, an oil-mill, a printing press, an ærated water factory, a cabinet factory, etc., in which it is intended that steam, water or other mechanical power is to be employed, has to make a written application accompanied with a block plan in duplicate showing therein the site of the engine, its horse-power and the drainage arrangements, etc., of the factory. In reporting upon such applications, the Sanitary Inspector has to note (1) the suitability or otherwise of the site proposed; (2) whether the locality is open or thickly populated, and whether suitable or not for the purpose and whether the factory will prove a nuisance; (3) the distance

from the public road and from the nearest dwelling house. If the site is disapproved on account of its being so situated that it would cause or prove a nuisance, the application is rejected after the place has been seen by the Executive Health Officer or his Assistant. If the site is approved, then the usual requirements as regards the flooring, drainage arrangements, sanitary conveniences, etc., the height of the chimney or an exhaust pipe, means of light and ventilation and the means of ingress and egress are demanded. As far as practicable, factories are not allowed under dwelling rooms or in a building the upper floors of which are occupied for human habitation. No part of the machinery is allowed to be attached to any part of the building, as a safeguard against accident.

While inspecting (under section 396 of the Act) if it is observed that a newly established factory, workshop or work-place is worked with steam, water, oil engine or other mechanical power, without the previous written permission of the Municipal Commissioner, and without carrying out fully the requirements of the Health Department, action is taken by the Health Department under section 390 (1) against the offender or offenders.

If, on inspection of a factory (under section 396), a place of public resort, market, or a place in which persons exceeding 20 in number are employed in any manufacture or business, or as workmen or labourers, it is found that such premises are without privy or urinal accommodation, action is taken by the Health Department, under section 249 of the Act, to enforce the provision of the necessary conveniences.

The following scale of sanitary accommodation for factories has been laid down in the Indian Factories Act of 1911 :—

Number of Operatives.	*Seats.*
Where the number of operatives does not exceed 20	1
Where the number of operatives exceeds 20 but does not exceed 35	2
Where the number of operatives exceeds 35 but does not exceed 50	3
Where the number of operatives exceeds 50 but does not exceed 150	4
Where the number of operatives exceeds 150 but does not exceed 200	5
Where the number of operatives exceeds 200	1 seat for every 50 or fraction of 50.

If females are employed, separate latrines screened from those of males and marked in the vernacular in conspicuous letter " for women only " shall be provided. Those for males shall be similarly marked " for men only."

In factories which employ more than 100 hands and which do not provide flushing arrangements in the latrines, one urinal shall be provided for every 100 operatives or fraction of 100.

In the case of smoke nuisance from a factory, workshop or work-place or mill, action is taken under section 391 of the Act by the Health Department. Since the passing of the Bombay Smoke Nuisances Act (VII of 1912), the Factory Inspector appointed by Government takes the necessary action in this direction.

ACTION BEFORE THE MAGISTRATE.

The procedure that is adopted in taking action under sections 257, 377, 375 and 250 (*b*) is as follows :—

When an offence is noted, or any such defects as described above are found to contravene the provisions of these sections, an offence sheet is made out by the Sanitary Inspector

(entering in it the nature of offence and the requirements necessary to remedy it) and submitted to the Assistant Health Officer's office, after being registered in the Ward Office. A printed notice under section or sections contravened is prepared in the office of the Assistant Health Officer, and issued under his signature under section 68 of the Municipal Act, as empowered by the Commissioner in this behalf. The notice if not signed but stamped with the *facsimile* of the signature of the Assistant Health Officer is deemed to be properly signed and considered legal, under section 487 (1).

The notice thus prepared is sent in duplicate, with the offence sheet, to the Sanitary Inspector for service on the party concerned. The Assistant Inspector or Sub-Inspector, who holds the authority from the Commissioner under section 483 of the Act to serve notices and summonses, takes the notice to the residence or the place of business of the person against whom it is issued and gives or tenders it, as required by section 484 (*a*), to the party concerned personally. If after repeated efforts the party named in the notice be not found at home or at his place of business and personal service be not effected, the notice is given or tendered to some adult male member or servant of his family, as per clause (*b*) of section 484. If the party resides somewhere in the suburb or elsewhere, the notice is served upon him by post under a registered cover, as per clause (*c*) of section 484. If the party keeps in hiding and avoids the service of the notice, permission of the Assistant Health Officer is obtained to affix the notice on some conspicuous part of the building or land, if any, to which the same relates, as per clause (*d*) of section 484 of the Act. When the service of the notice is effected by the Sub-Inspector or the Assistant Inspector, he makes the necessary endorsement under his signature in the form printed on the reverse of both the original and the duplicate notice. The original is then handed to the party concerned and the duplicate brought back with his signature thereon as an acknowledgment. In the body of the notice time is

prescribed in which the party should carry out the requirements mentioned therein. After the expiry of the notice, the Sanitary Inspector visits the premises and checks all the requirements mentioned in the notice. If all the requisitions have been fully complied with, the duplicate notice is endorsed and returned to the Assistant Health Officer's office to be filed. If, on the other hand, the notice is partly complied with or is not complied with at all, the duplicate notice is so endorsed and returned to the Assistant Health Officer who passes an order to prepare a summons. Summons is then prepared in duplicate, by the Notice and Summons Clerk in the Assistant Health Officer's office, on forms supplied by the Presidency Magistrate. Simultaneously, information of the Assistant Health Officer is prepared in a printed form and also a charge sheet. The information is then filed before the Magistrate on the next available court day. The Magistrate passes an order thereon for the issue of process, and the summons prepared in the Assistant Health Officer's office is presented to the Judicial Clerk of the Court, who signs it for the Magistrate.

Since the issue of Government Resolution No. 2306 of 24th March, 1914, (General Department), summonses are sent by the Presidency Magistrates to the Assistant Health Officers direct, and the same are served by the Inspector or Sub-Inspector of the Health Department independently of the Police. The service of the summons is effected in the same way as that of the notice as per section 484 of the Act. If the party evades the service of the summons, an order is obtained from the Magistrate for 'substituted service,' and the summons is pasted on some conspicuous part of the building or land to which it relates. If, between the time of the application for the summons and its issue and service, it is found that the party has carried out all the requirements mentioned in the notice, the service of the summons is withheld and, after the Sanitary Inspector has satisfied himself that the work has been done satisfactorily,

the case is taken as "complied with before the service of the summons," and the case is withdrawn on the Court day, under section 517 of the Municipal Act. A day previous to the returnable date of the summons, the Sanitary Inspector again visits, with his Assistant, the premises in respect of which the summons was served and checks the notice noting in his "Summons Book" how far the requisitions of the notice have been complied with. These notes are subsequently copied in the office charge sheets.

On the Court day the party, on whom the summons was served, appears in person or by a pleader, or by his agent holding a power-of-attorney, to answer the charge in the Magistrate's Court. The fair charge sheet is placed before the Magistrate and the office charge sheet remains in the hands of the Assistant Health Officer, who reads out from it the offence with which the respondent is charged. If the accused has carried out the work, after the service of the summons, the case against him is taken as "complied with," and the party is warned and discharged by the Magistrate. If the accused has not done anything to comply with the requisitions of the notice and pleads "guilty," he is convicted and fined under section 471 of the Municipal Act. If he pleads "not guilty," the Magistrate directs the evidence to be led and, on taking the evidence of the Sanitary Inspector or the Assistant Health Officer, decides the case as he thinks fit by inflicting a fine or by warning and discharging the accused.

The fines are paid in the Court the same day, and the total amount of fines recovered is paid by the Court into the Municipal treasury. Those who have no money to pay the fines there and then are allowed a week's time, and in case of default, distress warrants are issued by the Court and executed by the Police, with the assistance of a Sub-Inspector or an Assistant Inspector from the Municipality, on the presentation of the warrant. If the defaulter refuses to pay

the fine recoverable from him, the Police seize his goods and household furniture, etc., and recover the amount of fine by disposing of the goods by an auction sale.

If after the service of a summons the party fails to appear before the Magistrate, a warrant is ordered against him and the case is adjourned to the next Court day. The warrant signed by the Magistrate is then executed by the Police, with the assistance of the Sub-Inspector, who has served the summons, and the party is then released on bail.

A week or ten days after the conviction of the party, the Sanitary Inspector again visits the premises with a view to finding out if the party has since done anything to carry out the requirements mentioned in the notice. If he has, no further action is taken. If he has not, then a report to that effect is made to the Assistant Health Officer, who issues an after-conviction notice, and the same procedure as described above is repeated, and the party failing to comply with the after-conviction notice is punished under section 472, wherein a daily penalty is prescribed for each day the party continues to offend by neglecting or failing to comply with the requisitions lawfully made upon him.

The following is the procedure adopted in taking action under sections 248 (1) (*a*), (*b*), (*c*), 249, 249-A (*a*), (*b*).

Section 248 (1) :—

The Sanitary Inspector inspects a building and counts the number of rooms on all the floors and takes a census of the occupants thereof. He then counts the number of privy seats provided on the premises and takes a note of all these. If the premises are without privy accommodation or the number of privy seats is insufficient, an offence sheet is made out accordingly by the Sanitary Inspector, calling upon the owner to provide privy accommodation or an additional privy of as many seats as would be necessary in the proportion of one seat for every set of five rooms or twenty persons.

The Assistant Health Officer then addresses a letter to the owner concerned to provide such additional privy or water-closet accommodation as may be prescribed, or to urge his objections, if any, in fifteen days. If the letter remains un-replied to for a fortnight, a reminder is sent to the party. In the meantime, references are made by letter to the Municipal Engineering, Water and Drainage Departments as regards structural alterations that would be necessary for the location of privy seats, the pressure of water and the drainage arrangements of the premises. On receipt of replies, a letter is addressed to the Municipal Commissioner (with copies of replies from the Departments, and of the party's letter, if any, urging his objections) to apply to the Standing Committee for their approval to a notice being issued. After such approval is given, a notice is prepared in the Assistant Health Officer's office, and the same procedure as detailed above is adopted thereafter in taking further action.

In the case of action under clause (*b*) of section 248 (1), the same procedure as above is observed.

For action under clause (*c*) of section 248 (1), the Sanitary Inspector has to note and report the insanitary features and the grounds on which the existing privy is considered objectionable and requires to be converted into a water-closet. An offence sheet is submitted by the Sanitary Inspector and the rest of the procedure is the same as above.

Section 249 :—In the case of action taken under this section, the procedure is the same as under section 248 (1).

Section 249-A :—In taking action under this section, the procedure is the same as in respect of section 248, with the only exception that no reference is made in this case to the other Departments of the Municipality.

For action under section 381, the first step is to take a sample of water for analysis from the well, tank, ditch, or pool. After the receipt of the result of the analysis from the Municipal Analyst, an offence sheet is prepared by the Sani-

tary Inspector and submitted to the Assistant Health Officer's office to issue a notice to clean or fill up such well, tank, ditch or pool. The Assistant Health Officer prior to the issue of the notice addresses a letter to the party to carry out the requirements mentioned in the offence sheet, failing which an application is made to the Municipal Commissioner to get the Standing Committee's approval to a notice being issued under this section. On obtaining such approval, a notice is prepared and sent to the Municipal Commissioner for his signature and served on the owner and the same further procedure is then adopted as above.

In the case of action under sections 372 (*e*), (*f*), 384 (*b*) and 390 (1), no notices are issued, but a direct summons is applied for on the submission of an offence sheet by the Sanitary Inspector. The summons is then served and further proceedings are taken in the Court as described above.

The procedure in taking action under sections 379 and 379 A is as follows :—

The Sanitary Inspector takes a rough census of all the rooms of the house or *chawl*, against which it is intended to take action for over-crowding, and if he finds that the place is over-crowded, he prepares, under section 379, a notice which, after being signed by the Assistant Health Officer, is served, with a form of certificate, on the party concerned, who has to fill up a form giving details of the area of the room, etc., and the name of the occupant and return it to the Assistant Health Officer within seven days. If the party fails to do this, a complaint is filed before the Magistrate under section 379, and he is summoned before the Court for non-compliance. The Magistrate then passes an order or convicts and fines the defaulter under section 471. If the party furnishes the required information, the occupant of each room is called upon to give information about the number of persons occupying the room. The Sanitary Inspector then visits the premises with the certificate and verifies the measurements of

each room and takes an independent census of each room, either early in the morning or after 9 p.m. If on verification the statement given by the party does not agree with the result of the census taken, the matter is reported to the Assistant Health Officer, who files an information (in the same way as described above) before a Magistrate, who orders the issue of a process. The party then appearing in Court, the Magistrate gives an order to abate the over-crowding in ten days time, under section 379-A of the Municipal Act. Failure to comply with this order renders the party liable to the penalty prescribed under section 471 of the Act.

As a rule, action is taken generally against the owner of a house and in his absence against the person who receives the rent of the said premises, or who would be entitled to receive the rent thereof if the premises were let; against an agent or trustee who receives such rent on behalf of the owner; against an agent or trustee who receives the rent of, or is entrusted or concerned with, any premises devoted to religious or charitable purposes; and against a receiver, sequestrator or manager, appointed by any Court of competent jurisdiction to have the charge of, or to exercise the rights of the owner of, the said premises, under section 3 (*m*) of the Act.

Complaint of offences for which the Health Department has to take action should be made before a Presidency Magistrate within three months next after the commission of such offence, under section 541 (*c*).

If an offender under the Municipal Act declines to give his name and address, the Sanitary Inspector or his subordinate, under section 522, asks for the co-operation of the Police who arrest the offender under section 516 of the Act.

If any offender, placed before the Magistrate for contravening the provisions of any of the sections of the Municipal Act or for not carrying out the requirements lawfully demanded of him, disowns the liability and responsibility under section 477 of the Act, or proves his inability to carry out the work for want of sufficient funds, he is let off under section 500.

CHAPTER XVIII.

Meteorological Instruments.

Meteorology is the science of the weather, which word in itself denotes the general condition of the atmosphere, and especially of that portion of the atmosphere near the surface of the earth.

In the pursuit of meteorology, two duties present themselves, *viz.*, the accurate observation of various phenomena, *e.g.*, temperature, pressure, wind, humidity, cloud, &c., and secondly, the practical interpretation of the data obtained.

To be of practical value, all observations made in various parts of the world must be comparable and reduced to a common standard.

Temperature.

Temperature must be distinguished from heat, which is a thing something objective, whereas temperature is a mere condition of a body temperately heated or cooled.

It is measured by thermometers, the principle actuating them being the expansion and contraction of certain bodies with change of temperature. Liquids are best suited for ordinary purposes, as gases expand too much and solids too little to indicate small differences of temperature.

Mercury and alcohol are the two liquids most commonly used; mercury because of its low specific heat, equal expansion at different temperatures, low vapour pressure, low freezing-point, (−37.9°F.), and high boiling-point, (675.1° F.); and alcohol is used, because it does not freeze at the greatest known cold at atmospheric pressure.

For these reasons, mercury is used for recording fairly high temperatures and alcohol for low ones.

A thermometer consists of a capillary glass tube of uniform bore, hermetically sealed at one end and blown out at the other into a bulb which is filled with alcohol or mercury, the expansion or contraction of which is measured by a scale marked either on the tube itself or the frame to which it is attached. There are four steps in the manufacture of a thermometer, *viz.*, (1) Calibrating the tube or dividing it into parts of equal capacity. This is done by introducing a small column of mercury into the tube and finding out if it occupies the same length at different positions in the tube. If it varies, the tube is rejected as the bore is not absolutely uniform. (2) Filling the bulb or tube with mercury or alcohol and expelling all air by heat. (3) Curing, *i.e.*, laying aside the instruments for a year or so after they are filled and before graduating. This permits contraction of the glass and so prevents displacement of zero as, if graduated too soon after filling, thermometers read too high after a few months. Of recent years, however, this process of curing by laying aside has been obviated by means of the annealing oven, in which the tube is rapidly cooled from a temperature of 320° F. to atmospheric temperature in 14 days. (4) Graduation. In order to mark off a scale of temperatures, two points must be taken. These two points are the freezing and boiling-points of water.

In England and America, zero is the temperature obtained by mixing equal parts of snow and sale ammoniac. On the continent of Europe, zero represents the temperature of melting ice, a temperature 32° F. higher than that obtained by the former method which was first introduced by Fahrenheit. Consequently, when a Fahrenheit scale thermometer is put into melting ice, its scale will read at 32°.

Both in England and on the Continent, the other fixed point is obtained by nothing the temperature reached by water boiling in a metal vessel at the ordinary atmospheric pressure of 29.921 inches or 760 m. m. mercury.

Having noted carefully the manner in which these fixed points are obtained, we may pass on to the three scales in common use.

On the Continent the space between zero and boiling point is divided into 100 parts, and this division is known as the Centigrade or Celsius scale. Another scale introduced by Réaumur exists, in which the space between the extremes is divided into 80 parts only.

In England and America, however, where the Fahrenheit scale is in general use, the space between zero and boiling-point is divided into 212 parts. Owing to the different methods employed in obtaining zero, the temperature of melting ice on the Fahrenheit scale is 32° F.; therefore 100°C. or 80° R. equal 212° F. less 32, that is to say 180° F.; therefore 1° F.$=\frac{5}{9}$° C or $\frac{4}{9}$° R.

To convert Fahrenheit degrees into C. or R., one must first deduct 32, and then multiply by the relative value of the two degrees—

F. into C.$=(F-32)\ \frac{5}{9}=C.$

F. into R.$=F-32)\ \frac{4}{9}=R.$

Conversely, C. and R. degrees may be altered into Fahrenheit by adding 32 after multiplying by the ratio value.

C. into F.$=\frac{9}{5}$ C. + 32.

R. into F.$=\frac{9}{4}$ R. + 32.

To convert Centigrade into Réaumur, multiply by $\frac{4}{5}$;

or to convert Réaumur into Centigrade, multiply by $\frac{5}{4}$.

The Fahrenheit and Centigrade scales agree at –40°.

The boiling-point of a liquid is the temperature at which the pressure of its vapour equals that of the atmosphere upon it, and is influenced by (1) the nature of the liquid, (2) the pressure on it; the lower the pressure, the lower the boiling-point; (3) the nature of the vessel in which it is contained; the boiling-point is higher in a glass vessel than in a metal one; (4) the air dissolved in the fluid which lowers the boiling-point and (5) substances in solution which raise the boiling-point.

THERMOMETERS.

There are many varieties of thermometers in use, including standard thermometers, ordinary, maximum and minimum, self-recording and radiation thermometers.

A standard thermometer is merely one made with very great care to secure accuracy. Unless intended for use in very cold climates, it is usually made to contain mercury.

Ordinary thermometers should be occasionally checked against a standard one. They usually contain mercury.

Maximum thermometers.—There are several well-known forms.

Philip's maximum is a mercurial thermometer; it is so manufactured that a small bubble of air is introduced into the tube in such a manner as to separate a portion of the mercury from the remainder. To set the instrument, the bulb-end is lowered and the instrument is gently tapped until the detached portion almost joins the rest of the column. The instrument is placed in the horizontal position with, if anything, a slight depression of the bulb-end. On the temperature rising, the mercury expands and rises up the tube pushing the detached portion forward in front of it. On the temperature falling, the portion detached by a bubble of air is left behind.

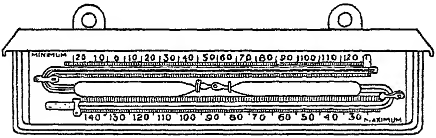
In reading the instrument, the end of the detached portion furthest from the bulb records the highest temperature reached.

Negretti's is also a mercurial thermometer and is suspended in the horizontal position. In this the detachment of a portion of the mercury is brought about, not by a bubble of air, but by a slight contraction of the lumen of the tube, which does not interfere with the expanding mercury but yet prevents the return thereof, as the

molecular attraction of the metal is insufficient to enable it to pass the obstruction. To set the instrument, gently tap it when the bulb is lowered, or gently swing it. The extremity of the detached portion farthest from the bulb shows the highest temperature reached.

Minimum Thermometer.—

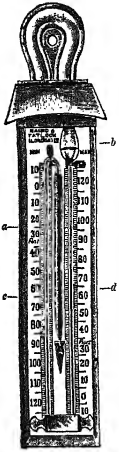
Rutherford's Minimum Thermometer.—In this, alcohol is the fluid used, and a small index, usually of glass is placed in the tube, which should be kept horizontal or nearly so. When the column of alcohol expands it flows past the index, but when it contracts it does not leave the index behind it but draws it along by capillary attraction, so that the point at which it ultimately rests indicates the lowest temperature attained.



RUTHERFORD'S THERMOMETER.

Registering Thermometers.—The oldest is probably that made by James VI and bears his name. The one most commonly used at present is Six's thermometer (see Fig. next page). It consists of a 'U' shaped tube (c-d), one end of which is drawn out into a long shaped bulb (*a*) filled with alcohol. The other end is expanded into a pear-shaped bulb (*b*) which is filled with alcohol, alcohol vapour and air.

The bend of the 'U' and a portion of each limb contain mercury and the alcohol in the bulbs (a, b) overflows into each of the limbs of the U-tube and rests on the mercury column. In both tubes there is a steel index.



SIX'S THERMOMETER.

The instrument is hung in the vertical position.

To set it, use a magnet and gently draw down each index until it rests on the surface of the mercury.

If the temperature rises, the alcohol in the bulb (*a*) and tube (*c*) expands and pushes the mercury down in the tube (*c*) and up in tube (*d*). When the temperature falls, the alcohol contracts and the air in bulb (*b*) forces the mercury down in tube (*d*) and up in tube (*c*).

In each case the reading is taken from the level of the lower end of the index. The temperature scale reads downwards in the tube (*c*) and upwards in the tube (*d*). Occasionally alcohol oozes past the mercury and runs from the tube (*c*) to the tube (*d*); this throws the reading entirely wrong and the instrument should be sent to the maker to remedy it.

CAUSES OF INTERCHANGE AND VARIATIONS OF TEMPERATURE.

An interchange of temperature between bodies heated to different degrees takes place owing to conduction, convection and radiation.

By *conduction* is understood the communication of heat from particle to particle in the same body. Its progress

is gradual and not instantaneous as is the case in radiation. The best conductors are the metals. Solids are better than liquids and the latter better than gases, but both liquids and gases as well as glass and wood are bad conductors.

Convection is the mode by which heat is transmitted through a fluid and the movements of the air to which we apply the term wind; the currents of the sea are also due to convection, which depends on the alteration in the density of the particles which causes them to rise to the surface when heated and *vice versa* when cooled.

Land and sea breezes are due to convection: the land during the day becomes warmer than the ocean and by radiation it imparts its heat to the air above it and this heated air rises allowing colder air from the sea to take its place. During the night, the land and sea both grow colder and the former more rapidly than the latter owing to the high specific heat of water, and consequently, the relative temperatures of the two being now reversed, a breeze blows from the land towards the sea.

Radiation.—Heat can be transmitted from one body to another without altering the temperature of the intervening medium. Heat thus propagated is said to be radiated. The property of radiating heat is not confined to luminous bodies such as fire, or a red hot ball, but bodies of all temperatures radiate heat. Certain laws apply to radiation of heat.

(*a*) Radiation takes place in all directions from a body.

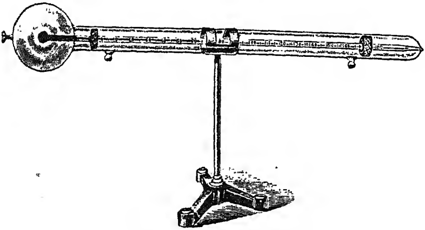
(*b*) In a homogeneous medium, radiation takes place in a right line, but in passing obliquely from one medium into another, as from air into glass, rays are refracted just as rays of light are.

(*c*) Radiant heat is propagated in vacuo as well as in air.

The intensity of radiant heat is (1) proportionate to the temperature of the source; (2) inversely as the square of the distance from the source; (3) less, the greater the obliquity of the rays with respect to the radiating surface.

Solar radiation.—The most intense of all sources of heat is the sun, the heat rays from which falling on the land are arrested at the surface, the amount of absorption depending on the conducting power of the soil; but on water, the rays penetrate some distance below the surface.

The intensity of the sun's rays is determined by means of Solar Radiation Thermometer which is a maximum mercury thermometer. The bulb and about an inch of the stem are blackened with lampblack in order to prevent loss of heat by reflection. The thermometer is placed in vacuo in a glass case. The readings are taken by placing the instrument directly in the sun about 4 feet from the ground and away from walls, trees and houses.



SOLAR RADIATION THERMOMETER.

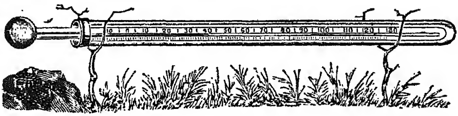
At the same time a maximum thermometer is similarly exposed away from trees, etc., but in the shade and not in vacuo. The excess of the temperature of the black bulb over that of the surrounding air, as measured by the ordinary maximum thermometer, is an approximate measure of the actual sun's rays.

Terrestrial radiation.—The heat received by the earth is again radiated from it, and as a result of this alternate absorption and radiation the mean temperature of the earth seldom varies.

As soon as the sun sets, the earth begins to radiate heat into space and thus to become chilled. This chilling process however is modified by (*a*) the presence of clouds which radiate back the heat to the earth, (*b*) the deposition of dew by which a large amount of latent heat is set free, (*c*) the presence of a wind which lessens the rapidity at which the earth cools owing to the fact that the earth comes in contact with the air of the upper as well as the lower strata of the atmosphere due to the movements caused by the wind, (*d*) the surface of the earth which receives a certain amount of heat from the air in contact with it, and also by (*e*) radiation downwards from the air above it.

Similarly, the radiation of heat from water is modified, because (1) water has greater specific heat and, therefore, cools more slowly than land, (2) the cooler particles of water sink and are replaced by warmer ones and this process is very slow ; thus the temperature of the surface of the water can only be lowered by the temperature of the whole mass falling, which will require a longer or shorter time depending on the depth of water.

The loss of heat due to terrestrial radiation is measured by placing *the terrestrial radiation thermometer* on short supports about 4 inches high from the ground, preferably on a grass plot.



TERRESTRIAL RADIATION THERMOMETER.

Should snow lie on the ground, it can be placed directly on the snow.

At the same time a minimum thermometer is exposed in the usual way and the difference between it and the one laid near the ground is recorded as the amount of terrestrial radiation.

Due to the distance of the sun from the horizon, the temperature of a place varies from hour to hour. The mean temperature of the day is determined in most observatories by recording the height of the thermometer at every moment of the day by photography.

Failing this, it can be estimated—

(1) by taking two readings at twelve hours interval *e.g.*, 8 A.M. and 8 P.M. or 9 A.M. and 9 P.M.; the mean of these readings more or less approximates the true mean;

(2) from three daily observations at say: 6 A.M., 2 P.M. and 9 P.M.

The daily minimum temperature is about 1 hour before sunrise and the maximum about 2 hours after noon.

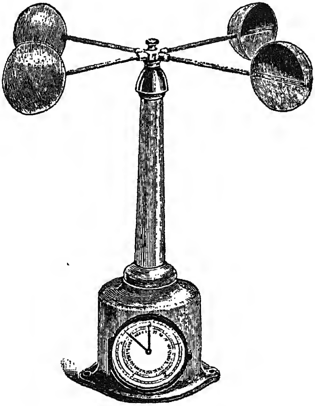
The mean temperature of a place is determined by adding the mean temperature for several months and then dividing by the number of the months embraced by the observations.

In exposing a thermometer it is essential to see that a constant circulation of air is kept up round the thermometer bulb and that this air has not just previously passed over a very hot or a very cold surface; the bulb must also be protected from the direct rays of the sun and from radiation from objects in the immediate vicinity. To meet these requirements, Stevenson's screen is largely used. It consists of a box on legs 4 feet high. It is open below, the sides are lowered and the roof is ridged. It should be placed at least 20 feet away from any building or wall.

Maximum and minimum thermometers are usually read once a day, *viz.*, at 9 A.M.

Anemometers—These are instruments for recording the velocity of the wind. Robinson's instrument is the one

generally employed. It consists of an upright iron stand, to the upper end of which are attached four arms, at right angles to one another. The free ends of these arms carry hemispherical cups. When the instrument is set in the breeze, the wind exerts greater force upon the hollow surfaces of the cups than upon their rounded surfaces ; rotation, therefore, occurs and the stronger the wind, the faster the rotation. The revolving cups set in action a train of clockwork and the velocity of the wind is recorded on a series of dials. It was supposed by Robinson at first that the cups moved with about one-third of the velocity of the wind. It is now known that this is not correct. The velocity of the wind may be taken as about $2\frac{1}{2}$ times the velocity of the cups, when the instrument is so constructed that the cups are 9 inches in diameter, and the arms 24 inches in length. In the case of low velocities, allowance should be made for friction as well.



ANEMOMETER.

The instrument should be placed away from trees and buildings and, if possible, above the level of surrounding buildings.

THE BAROMETER OR MEASURE OF WEIGHT OF THE ATMOSPHERE.

The atmosphere at sea-level exerts a pressure of about 14.64 lbs. per square inch.

It can support a column of mercury 29.92 inches high. Taking the density of water as 1 and of mercury as 13.59, the column of water sustained would be 33.9 feet.

Similarly, the atmospheric pressure can sustain a column of alcohol 42.4 feet.

For general use mercury is chosen, as it is portable and the tube containing it is not so unwieldy as in the case of water; moreover, in the water barometer the space above the water is not a true vacuum, as it very nearly is in the mercurial barometer.

In its simplest form, a barometer consists of a glass tube about 33 inches long, closed at one end and open at the other. The tube is completely filled with mercury and then inverted with its open end downwards in a vessel containing mercury, great care being taken to see that no air enters the tube. The tube being held in a vertical position, the column of mercury in it sinks and, after oscillating for some time, finally comes to rest at a point about 30 inches above the mercury in the trough. The space thus left between the mercury and the top of the tube is known as the Torricellian vacuum.

Certain precautions must be adopted in filling a barometer, amongst which are—

(*a*) The mercury used must be pure ; (*b*) the tube must be perfectly dry, otherwise, any moisture present rises as

vapour to the top of the tube and causes depression of the mercury; (*c*) the mercury must be boiled to expel air and moisture, and (*d*) the tube must be of uniform calibre.

The siphon barometer consists of a bent tube of uniform calibre; one of the branches is much longer than the other. The longer branch which is closed at the top is filled with mercury, while the shorter branch which is open serves as a cistern. The difference between the two levels is the height of the barometer.

The cistern barometer.—The tube, as previously described, is filled with mercury and inverted into a vessel or cistern also containing mercury, and the whole is fixed to a scale.

There are certain sources of error in the ordinary cistern barometer—

(*a*) Capillarity, (*b*) Capacity, (*c*) Temperature, (*d*) Height and (*e*) Index.

(*a*) *Capillarity.*—The effect is to depress the column of mercury, the amount of depression varying with the internal diameter of the tube. The smaller the diameter, the greater the error.

The correction is always positive.

(*b*) *Capacity.*—This error is the result of the rising and falling of the mercury in the tube and the consequent ever-varying level of mercury in the cistern.

It is evident that given a tube of mercury standing in a cistern of the same metal, a fall of the column must produce a rise in the level of the mercury in the cistern.

If, therefore, the scale of the instrument be laid off from zero at any fixed point in the cistern, the readings will be wrong at every point, but one. The movements of the

column will always be too small in the ratio which the area of the cistern bears to the area of the tube.

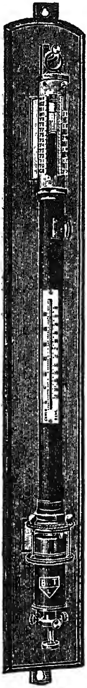
Various devices have been proposed to overcome this.

Capacity correction.—The ratio between the area of the tube and the cistern is noted and recorded on the scale, *e.g.*, capacity $\frac{1}{40}$. On the scale there is always a certain height which is correctly marked; this may be called the neutral point. Now, if the mercury falls below this, the height read will be too great, because the level of the mercury in the cistern is above zero; and *vice versa*. To apply this correction, multiply the difference between the observed height and the neutral point by the capacity correction and add it to the reading when the column is higher and subtract when it is lower than the neutral point or height.

Kew pattern.—No attention is paid to the mercury in the cistern, but the graduations on the scale are only in nominal inches, being shorter than true inches from above downwards in proportion to the relative size, of the tube and cistern.

Fortin pattern of barometer differs from the ordinary barometer in the shape of the cistern which consists of a glass cylinder through which the mercury can be seen. This is closed at the top by a box-wood disc fitted on the under-surface of the brass cover. Through this passes the barometer tube which is drawn out at the end and dips into the mercury in the cistern. The bottom of the cistern is made of leather and can be raised or lowered at will by means of a screw. Attached to the top of the cistern is a small piece of ivory tapering to a point (called the *fiducial point*). Before taking a reading of the barometer, the mercury in the cistern should be raised or lowered until it just touches the fiducial point. The error seen in the ordinary barometer is removed by laying off the scale from the extremity of this fiducial point. The inches marked on the scale are true ones.

A barometer should be placed indoors in a good light but not in the sun, and it should be suspended vertically.



FORTIN BAROMETER.

The scale for reading the height of the column of mercury is divided into inches, tenths and half-tenths ($\frac{1}{20}$) of inches; and, to obtain more accurate readings than the scale alone allows, a sliding scale or vernier is attached, which serves to indicate the amount of space occupied by the Hg. between the half-tenth lines. The vernier scale is divided into 25 equal parts, which correspond to 24 half-tenth divisions on the barometer scale. Each division on the vernier is, therefore, equal to $\frac{24 \times \cdot 05}{25}$ inch, *i.e.*, $\frac{1.2}{25}$ inch$=\cdot 048$ inch, and is thus less by $\cdot 002$ inch than a half-tenth division on the barometer scale.*

To use the vernier, adjust it so that its lower edge just corresponds with the top of the meniscus of the mercury, no light being visible between them. If the lower edge exactly corresponds with one of the smaller divisions of the main scale, then this division represents the exact reading of the barometer.

But if the lower edge of the vernier does not so correspond exactly, then one must follow up the scale until the point is reached where a vernier division and a principal scale division exactly coincide.

* Some verniers are prepared by dividing 9 divisions of the main scale, each $\frac{1}{10}$th of an inch, into 10 divisions on the vernier. The difference between the divisions of the two scales would then be ·01 of an inch.

Now count off the number of vernier divisions from the top of mercury upto where the two scales correspond and multiply by ·002. Add the result to the reading shewn on the principal scale and so obtain the reading corresponding with the top of the mercury.

Having read the barometer with the aid of a vernier, there are certain corrections which it is necessary to apply.—

(1) *Index error.*—This lies in the instrument itself; it is generally the same at all parts of the barometric scale and is very small. It may be positive or negative, the fact being usually stated on a certificate.

(2) *Capillarity.*—The correction is always positive. These two errors are often grouped together and an inclusive figure is given in a certificate with the barometer.

In the siphon barometer, errors for capillarity and capacity do not exist and are, therefore, not allowed for.

(*c*) *Correction for temperature.*—Two corrections have to be made here, one for the expansion of the mercury, and the other for that of the brass.

For purposes of accurate comparison, all readings should be reduced to 32° F. or 0° C.

Mercury expands on heating and contracts on cooling. The co-efficient of expansion is 0·0001 for every degree F. rise of temperature, *i.e.*, a given volume of Hg. at 32° F. increases 0·0001 of this volume for every rise of 1° F. above 32° F.

To correct, use formula—

$$\text{Height at } 32^\circ \text{ F} = \frac{\text{Indicated height.}}{1 + \cdot 0001\,(t-32)}$$

e.g., Barometer reads 29·452 inches; Thermometer 62° F. To find height at 32° F.

$$\text{Height} = \frac{29 \cdot 452}{1 + \cdot 0001 \times 30} = \frac{29 \cdot 452}{1 \cdot 003}$$

$$= 29 \cdot 363 \text{ inches.}$$

The index is made of brass, and this also expands on heating and contracts on cooling.

The necessary corrections can be obtained from a special table.

(*d*) *Correction for height.*—For purposes of comparison all barometric readings are reduced to mean sea-level.

As a rule, mercury falls about 1 inch for every 900 feet ascended—*i.e.*, about $\frac{1}{900}$ or 0·001 inch for every foot ascended, and this amount multiplied by the number of feet ascended must be added to the observed height, if the place be above the standard level. Temperature falls about 1° for every 300 feet ascended.

Aneroid barometer, i.e., a barometer without a liquid. It consists of a metal box from the interior of which the air is exhausted. Any increase of atmospheric pressure compresses the box and the motion is by suitable levers made to move the hand on the face of the aneroid. It can never be relied upon for fixed stations, as it may work extremely well for a time and then go hopelessly wrong. Checked against a standard barometer frequently, it is valuable in measuring altitudes. It should always be read in one position and not at one time hanging and at another lying flat.

To ascertain the altitude by a barometer.—Read the aneroid to the nearest $\frac{1}{100}$ of an inch. Subtract the upper station reading from the lower.

Neglect the decimal point and multiply by 9. Result is in feet.

Note.—If temperature is above 70, or upper barometric reading is below 26, then multiply by 10.

Another method :—

(1) Take the mean of the barometric readings of the upper and lower stations.

(2) Take the mean of the temperatures of the upper and lower stations.

(3) From a table find the height of a column of air which will at this mean pressure and temperature support 1 m.m. of mercury.

(4) Multiply this by the difference between the two barometric readings.

(5) Result is in meters.

HUMIDITY.

The term implies the amount of vapour present in the air which is also called the degree of humidity. By *absolute humidity* is meant the amount of vapour present in a given volume of the air, while *relative humidity* represents the amount of vapour present, expressed as a percentage of that amount necessary to cause saturation of the air at that temperature.

The amount of vapour in the air is not a measure of its humidity, for the air is for the most part drier in summer than in winter, although the amount of vapour present in the former is much greater.

At all ordinary temperatures, water gives off vapour and it evaporates into dry air as into a vacuum, but the volume of the resulting moist air is greater than that of the original dry air.

The higher the temperature of the air, the greater the pressure of the water vapour, *i.e.*, the amount of moisture which the air can hold is constantly varying with its temperature. Thus at 32° F. a cubic foot of air can take up only 2·10 grains of aqueous vapour, while at 100° F. it can take up as much as 19·84 grains. When the air is so full of moisture that it can hold no more, it is said to be saturated.

The volume of moist air is greater than that of dry air, *e.g.*, a cubic foot of dry air at 60° F. weighs 536·3 grs. and can take up 5·77 grs. of water. The product, however, is not one cubic foot of moist air weighing 542·1 grs. but 1·0176 cubic feet, and a cubic foot of the same moist air weighs only 532·7 grains.

As a rule, the water present is only about 70 or 75 per cent, of the amount required to saturate it (relative humidity); but if the air is cooled, the same amount of aqueous vapour may suffice to saturate it, *e.g.*, 100 cubic feet of air, three parts saturated at a temperature of 70° F., would hold 600 grs. of aqueous vapour; if for some cause or other the temperature of the air be reduced to 61° F., then that volume of air would become quite saturated, because at that temperature it could only hold 600 grs.; and if the temperature be still further reduced, say to 56° F, *it could only hold* 500 *grs. and the* difference therefore (*viz.*, 100 grs.) would be deposited as mist, dew or rain.

In perfectly pure air, a pressure of vapour may be maintained greater than that corresponding to the temperature of saturation.

It is on the presence of solid particles of dust in the air that the formation of mists and fogs depends, the precise degree of mist or fog depending on the amount of dust present and on the size and constitution of the particles. Such atmospheric dust probably consists of fine salt particles from the sea, meteoric dust, products of combustion, and animal, vegetable and mineral matter.

When the number of dust particles is large or their size is considerable, and the quantity of vapour condensed is small, we get the phenomenon of a town fog or so-called dry fog.

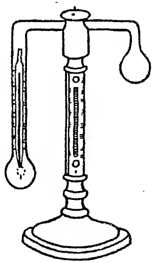
Sea fogs probably occur in air, which is comparatively dry, because the nucleus in their case consists largely of salt grains derived from spray or surf which have a great affinity for moisture.

The formation of dew is analogous; it is formed by the condensation of aqueous vapour on the ground or on blades of grass, instead of round nuclei of dust in the air as in the case in fogs. The earth cools at night by radiation and this reduces the temperature of the air in its vicinity and at length a point is reached when the air, at that particular temperature, is unable to support the amount of water vapour contained in it and consequently the surplus is deposited as dew. The particular temperature at which this deposition occurs is known as *dew-point*, and it is from the determination of this that the amount of moisture present in the air is calculated.

The instruments used for the determination of dew-point are known as hygrometers and there are several patterns. Some give the information required in a direct manner, *e.g.*, Daniell's, Regnault's and Dine's, others require certain calculations in order to arrive at a result, *e.g.*, the dry and wet bulb thermometers.

DIRECT HYGROMETERS.

Daniell's hygrometer consists of a bent glass tube supported on a stand. At the end of each rectangular bend is a bulb.



DANIELL'S HYGROMETER.

The lower bulb is of black glass or white glass covered with a gold band and contains ether, and a thermometer the stem of which is visible in the tube above. The other bulb and the remainder of the glass tube contain the vapour of ether, and the bulb itself is covered with muslin.

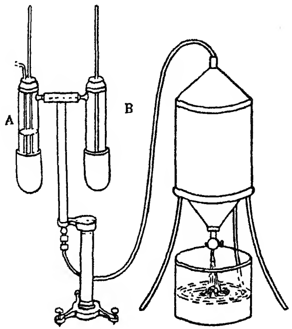
To use the instrument.—All the ether should be brought into the lower bulb. The muslin on the upper bulb is then wetted with ether and by its evaporation the temperature of the bulb is lowered; this causes a condensation of the ether vapour in the tube and bulb, and as a result an increase of evaporation from the ether in the black bulb with, in consequence, a lowering of the temperature in that bulb. As soon as the temperature of the black bulb sinks to the dew-point, then the black surface or the gold band is dulled by the deposit of atmospheric vapour and this temperature is at once read off by means of the contained thermometer. The wetting of the upper bulb with ether is then stopped and since there is now no evaporation of ether, the moisture deposited on the lower bulb disappears. The temperature is again taken at the moment of disappearance of the moisture from the bulb. The mean of the two temperatures gives the dew-point.

A thermometer is generally attached to the stand and gives the temperature of the room.

On account of the low boiling-point of ether, this hygrometer cannot be used in very hot climates. (The boiling point of ether is 36° C. or 97° F.).

The temperature at the moment of the deposit of moisture on the ether bulb is really a little lower than the dew-point; if, however, the instrument be left alone and the temperature noted at the moment of the disappearance of the dew, the mean of the two readings will give the correct dew-point.

Regnault's hygrometer is a modification of Daniell's.



REGNAULT'S HYGROMETER.

It consists of two thin glass tubes A and B, corked at one end and fitted into two thin silver thimbles suspended on a stand; a thermometer is placed in each, the stems of which pass through the corks.

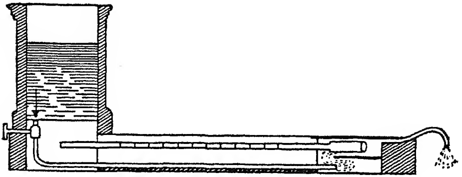
The tube A contains some ether, and a glass tube opening below the ether passes through the cork and opens into the air. Tube A is connected with an aspirator.

Tube B holds a thermometer which indicates air temperature.

To use the instrument.—The cock of the aspirator is turned on, air is drawn through A and the temperature is noted the moment the silver thimble becomes tarnished with moisture: The aspirator is then stopped, the moisture from the thimble disappears and the temperature is again noted at this moment. The mean of the two temperatures represents the dew-point.

Dine's hygrometer is of a very simple form. It consists of a wooden stand in which is a vessel containing powdered ice.

From this proceeds a pipe leading to a space containing a thermometer. The roof of this space is covered in by blackened glass.

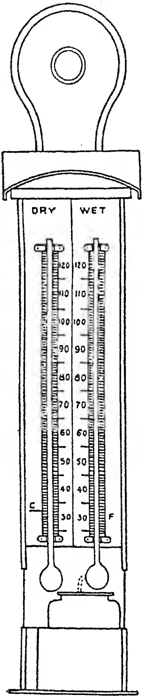


DINE'S HYGROMETER.

Cold water passes through the space beneath the glass plate, until the glass becomes dull from moisture deposited on it. The moment this occurs, the temperature of the contained thermometer should be read off. The flow of water is then stopped, the moisture disappears and the temperature again noted. The mean of these two readings gives the dew-point.

De Saussure's hair hygrometer depends for its action on the fact that a hair elongates when moistened and contracts on being dried. The hair is deprived of all grease by washing it in ether or in liquor potassæ, and it is then fastened at one end and to the other end is attached a small weight to stretch the hair. The hair passes round a movable axis, which carries a lever pointing to a graduated arc. As the hair expands or contracts, it rotates the axis and the indicating lever. The arc is graduated first for perfectly dry air=0, and then for air saturated with moisture=100, and the intervening space is graduated accordingly.

The wet and dry bulb thermometer consists of two thermometers set in a frame side by side. The bulb of one of these is covered with muslin which, by the aid of a piece of wick and a small receptacle for water placed under the thermometer, is kept constantly wet.



THE WET AND DRY BULB HYGROMETER.

If the air is saturated with moisture, no evaporation takes place from the wet bulb and its reading will be the same as that of the dry bulb thermometer which gives the reading of the ordinary temperature of the air. If, however, the air be not saturated, evaporation takes place from the wet bulb, thereby lowering its temperature. The drier the air the faster the evaporation taking place, and consequently the greater the cooling and the fall in the thermometer. In frosty weather the muslin may be hard, in which case one must merely brush it over with water.

From the wet and dry bulb readings the dew-point can be calculated, and from the dew-point the weight of water present in the air and the humidity of the air.

The dew-point can be very roughly ascertained (*a*) by taking it to be as much below the wet bulb reading as that is itself below the dry bulb reading; or (*b*) by the use of Glaisher's factors, thus: Take the difference between the dry and wet bulb readings: multiply this by the factor opposite the dry bulb reading in Glaisher's Table; deduct the product from the dry bulb reading and the result is the dew-point.

This may be expressed by the formula—

$D = Td - F\ (Td - Tw)$,

where /D = Dew-point.

Td = Dry bulb temperature.

Tw = Wet bulb temperature.

F = factor in Glaisher's table opposite dry bulb temperature.

Precautions in using the wet and dry bulb thermometers:—

(1) Both thermometers must be exactly alike.

(2) Free circulation of air must be maintained round the wet bulb.

(3) The vessel containing the water should be small and placed some inches from both bulbs.

(4) The muslin must be kept thoroughly moist, but not to allow collection of water at the bottom of the bulb.

EXAMPLE OF THE WORKING OF GLAISHER'S FACTORS.

Dry bulb reading	84
Wet bulb ,, ...	76

Factor opposite dry bulb reading of 84=1.66.

Then,

$$84 - 76 = 8$$
$$8 \times 1.66 = 13.28$$
$$84 - 13.28 = 70.72^\circ = \text{the dew-point.}$$

GLAISHER'S FACTORS.

Reading of Dry bulb Therm.	Factor.	Reading of Dry bulb Therm.	Factor.	Reading of Dry bulb Therm.	Factor	Reading of Dry bulb Therm.	Factor.
°		°		°		°	
10	8.78	33	3.01	56	1.94	79	1.69
11	8.78	34	2.77	57	1.92	80	1.68
12	8.78	35	2.60	58	1.90	81	1.68
13	8.77	36	2.50	59	1.89	82	1.67
14	8.76	37	2.42	60	1.88	83	1.67
15	8.75	38	2.36	61	1.87	84	1.66
16	8.70	39	2.32	62	1.86	85	1.65
17	8.62	40	2.29	63	1.85	86	1.65
18	8.50	41	2.26	64	1.83	87	1.64
19	8.34	42	2.23	65	1.82	88	1.64
20	8.14	43	2.20	66	1.81	89	1.63
21	7.88	44	2.18	67	1.80	90	1.63
22	7.60	45	2.16	68	1.79	91	1.62
23	7.28	46	2.14	69	1.78	92	1.62
24	6.92	47	2.12	70	1.77	93	1.61
25	6.53	48	2.10	71	1.76	94	1.60
26	6.08	49	2.08	72	1.75	95	1.60
27	5.61	50	2.06	73	1.74	96	1.59
28	5.12	51	2.04	74	1.73	97	1.59
29	4.63	52	2.02	75	1.72	98	1.58
30	4.15	53	2.00	76	1.71	99	1.58
31	3.60	54	1.98	77	1.70	100	1.57
32	3.32	55	1.96	78	1.69		

The moisture present in the atmospheric air exerts a certain amount of pressure which forms a part of the atmospheric pressures indicated by barometers. This pressure is called the "elastic force of the vapour" or "the tension of aqueous vapour". The aqueous tension is greatest near the equator and least near the poles; greater over the ocean than over dry land, in summer than in winter, by day than by night and at sea-level than in the upper strata of the atmosphere.

The aqueous tension can be ascertained by reference to tables. It is important for the calculation of relative humidity which is done as follows :—

$$\text{Relative humidity} = \frac{\text{aqueous tension at dew-point}}{\text{aqueous tension at air-temperature.}} \times 100$$

Example :—

Dew-point=70·7.

Temperature of air=84.

The aqueous tension at dew-point=0.750.

The aqueous tension at air temperature=1.165.

$$\text{R. H.}=\frac{0.750}{1.165}\times 100=64.4 \text{ per cent. of saturation.}$$

TABLE OF TENSIONS OF AQUEOUS VAPOUR.

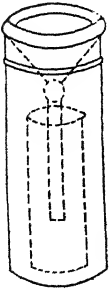
Temp. Fahr.	Tension in inches of Mercury.	Temp. Fahr.	Tension in inches of Mercury.	Temp. Fahr.	Tension in inches of Mercury.	Temp. Fahr.	Tension in inches of Mercury.
0	0.044	24	0.129	48	0.335	72	0.785
1	0.046	25	0.135	49	0.348	73	0.812
2	0.048	26	0.141	50	0.361	74	0.840
3	0.050	27	0.147	51	0.374	75	0.868
4	0.052	28	0.153	52	0.388	76	0.897
5	0.054	29	0.160	53	0.403	77	0.927
6	0.057	30	0.167	54	0.418	78	0.958
7	0.060	31	0.174	55	0.433	79	0.990
8	0.062	32	0.181	56	0.449	80	1.023
9	0.065	33	0.188	57	0.465	81	1.057
10	0.068	34	0.196	58	0.482	82	1.092
11	0.071	35	0.204	59	0.500	83	1.128
12	0.074	36	0.212	60	0.518	84	1.165
13	0.078	37	0.220	61	0.537	85	1.203
14	0.082	38	0.229	62	0.556	86	1.242
15	0.086	39	0.238	63	0.576	87	1.282
16	0.090	40	0.247	64	0.596	88	1.323
17	0.094	41	0.257	65	0.617	89	1.366
18	0.098	42	0.267	66	0.639	90	1.410
19	0.103	43	0.277	67	0.661	91	1.445
20	0.108	44	0.288	68	0.684	92	1.501
21	0.113	45	0.299	69	0.708	93	1.548
22	0.118	46	0.311	70	0.733	94	1.596
23	0.123	47	0.323	71	0.759	95	1.646

RAINFALL.

As the clouds consist of particles of water, they are constantly raining; but between the clouds and the earth there is usually a non-saturated belt of air or region, where these particles of water, when small, are evaporated before they reach the earth. The physical cause of rain is the sudden chilling of comparatively warm moist air, either by its ascent into the upper and colder regions of the atmosphere or by its contact with cold mountain slopes. It has been estimated that one gallon of rainfall, by its condensation from vapour into liquid form, gives out latent heat enough to melt 75 lbs.

of ice. The condensation of one grain of aqueous vapour gives out enough heat to raise 536 grains of water 1°C.

To collect and measure the rain, rain-gauges are used. There are several forms of gauges. The simplest consists of a copper funnel leading to a bottle or receiver in which the rain is collected and from which it is drawn and measured. The funnel has a sharp circular rim and is generally either 5 or 8 inches in diameter; the rim should be truly horizontal, else the gauge will catch too much or too little according to the direction and force of the wind. The tube leading from the funnel to the bottle should be long and narrow so as to lessen loss by evaporation.



RAIN-GAUGE.

The best position to place the gauge is on the ground about one foot above the level of the earth, in an exposed position free from trees, houses, etc. No object ought to subtend a greater angle with the horizon than 20° in any direction from the gauge. Others, however, contend that the best position is to bury it in the earth making its top just even with the surface of the ground.

More rain is collected on or near ground level than on the top of a building, or on a stand at a height above the ground. This has been ascribed to the fact that the rain drops, which are generally colder than the layers of the air which they traverse, condense the aqueous vapour in these layers and therefore constantly increase in volume; hence more rain falls on the surface of the ground than at a certain height. But it has been objected that the excess of the quantity of rain which falls over that at a certain height is six or seven times that which could arise from condensation, even during the whole course of the raindrops from the clouds to the earth.

The difference must therefore be ascribed to purely local causes; and it is now assumed that it arises from eddies produced in the air about the rain-gauge which are more perceptible the higher it is from the ground; and as these eddies disperse the drops which would otherwise fall into the instrument, they diminish the quantity which it receives. In any case it is clear that, if rain-drops traverse moist air they will, from their lower temperature, condense aqueous vapour and increase in volume, and *vice versa.*

Snow and hail collected in the rain-gauge can be melted for measurement by adding a known volume of warm water and deducting that quantity in subsequent calculations.

To calculate the quantity of rain intercepted by the rain-gauge, the rain collected in the receiver is measured in a graduated glass vessel, the divisions of which correspond to $\frac{1}{2}$ inches and $\frac{1}{10}$th inches, marked in proportion to the area of the gauge, which should always be either 5 or 8 inches in diameter.

For example.—The gauge is 8 inches in diameter.

The area of the opening, therefore, is $\Pi\rho^2$ or $\delta^2 \times 0 \cdot 7854$; $= 16 \times 3 \cdot 1416 = 50 \cdot 2656$ sq. inches; one inch of rain-water on 50 square inches of the horizontal surface gives 50 cubic inches of water $= 29 \cdot 08$ fluid ounces.

Therefore, place 29·08 fluid ounces of water into the glass measure and mark off the level of the surface of the water. This mark represents one inch of rain in that particular 8-inch gauge. The height marked off is then sub-divided into $\frac{1}{10}$th of an inch, etc.

The measuring glass must be held quite level when taking readings. Readings are best taken at 9 a. m. The gauge should be overhauled occasionally to see if there is any sign of leakage or damage.

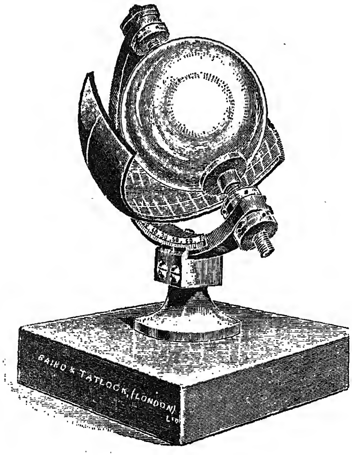
The amount of rain which falls varies very much, of course, with the place. In England and Wales the average rainfall is 33.76 inches; in Scotland 46.56; in Ireland 38·54.

Other things being equal, most rain falls in hot climates, for there the vaporisation is most abundant. The rainfall decreases, in fact, from the equator to the poles. So also the quantity varies with the season. In Paris, in winter, it is 4.2 inches, in summer 6.3.

The heaviest annual rainfall of any place is on the Khasi Hills in Bengal, where it is 600 inches.

The rainfall diminishes with the height of a station above the sea-level at the rate of 3 or 4 per cent. for each 100 feet above the sea-level.

An inch of rain on a square yard of surface = 4·67 gallons, or 22622 gallons per acre or 10 tons.



SUNSHINE-RECORDER

Sunshine—To keep records of the daily amounts of sunshine, Campbell-Stokes sunshine recorder is the one most frequently used. The instrument consists of a large spherical lens, mounted on a stand, which concentrates the rays of the sun on a graduated strip of mill-board fixed in the frame at the proper focal distance. When the sun shines, a charred line is burnt in the mill-board which ceases when the sun is hidden by the clouds. The number of hours corresponding to the charred portion can be easily ascertained. The result is usually expressed as a percentage of the possible sunshine *i.e.*, if the sun is above the horizon for 10 hours and the record is for 2 hours only, the sunshine equals 20 per cent. of the possible amount.

APPENDIX.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES.

The initial unit of the Metric System is the metre, or unit of length, which was intended to represent one ten-millionth part of the earth's quadrant, or one forty-millionth part of the circumference of the earth around the poles. In reality the British standard metre is the distance at a temperature of 0°C., between two fine lines on a bar of iridio-platinum in the possession of the Board of Trade. The multiples and sub-divisions of this and all the other units are obtained by the use of decimals, and for this reason the system is also known as the *decimal system.* The multiples are designated by the Greek prefixes, *deka*=10; *hecto*=100; *kilo*=1,000; *myria*=10,000. For the sub-divisions, Latin prefixes are employed; *deci*=1/10; *centi*=1/100; *milli* 1/1,000. Thus for measures of length we have the expressions given in the following table, which also shows the abbreviations employed, and the equivalents in the Imperial standards of measurements :—

1 Myriametre	Mym.	=	10000.0 M.	=	6.2137	miles.
1 Kilometre	Km.	=	1000.0 M.	=	0.6214	mile.
1 Hectometre	Hm.	=	100.0 M.	=	109.361	yards.
1 Dekametre	Dkm.	=	10.0 M.	=	32.8084	feet.
1 *Metre*	M.	=	1.0 M.	=	39.3701	inches.
1 Decimetre	dm.	=	0.1 M.	=	3.937	,,
1 Centimetre	cm.	=	0.01 M.	=	0.3937	inch.
1 Millimetre	mm.	=	0.001 M.	=	0.0394	,,
1 Micron	u.	=	0.000001 M.	=	0.000039	,,

The unit of mass in the metric system is the *Gramme.* This was derived from the metre, and represented the weight of one cubic centimetre of water, or the quantity of distilled water, at its maximum density, 4°C. (39.28°F), which would fill the cube of one-hundredth part of a metre. It is now officially defined as the one-thousand part of the cylindrical iridio-platinum standard kilogram weight in the possession of the Board of Trade. The relative value of the gramme, together with its multiples and sub-divisions, as compared with the Imperial standards of weight, may be seen from the following table :—

1 Myriagram	Mygm.	=	10000.0 Gm.	=	22.0461	pounds.
1 Kilogram	Kgm.	=	1000.0 Gm.	=	2.2046	,,
1 Hectogram	Hgm.	=	100.0 Gm.	=	3.5274	ounces. avoir.
1 Dekagram	Dkgm.	=	10.0 Gm.	=	154.3236	grains.
1 *Gramme*	Gm.	=	1.0 Gm.	=	15.4324	,,
1 Decigram	dgm.	=	0.1 Gm.	=	1.5432	,,
1 Centigram	cgm.	=	0.01 Gm.	=	0.1543	grain.
1 Miligram	mgm.	=	0.001 Gm.	=	0.0154	,,

From the unit of mass (the gramme) is derived the unit of the measure of capacity, or *Litre.* It is represented by the capacity at 0°C. of a cylindrical brass measure in the possession of the Board of Trade. This Litre measure at 0°C. has a capacity corresponding to the volume at

4°C. of a kilogram of distilled water, the weighing being made in air but reduced by calculation to a vacuum. The multiples and sub-divisions of the Litre, with their equivalents in Imperial fluid measure are :—

1 Myrialitre	Myl.	= 10000.0	L.	=	2199.76 Imperial gallons.
1 Kilolitre	Kl.	= 1000.0	L.	=	219.976 ,, ,,
1 Hectolitre	Hl.	= 100.0	L.	=	21.9976 ,, ,,
1 Dekalitre	Dkl.	= 10.0	L.	=	2.1998 ,, ,,
1 Litre	L.	= 1.0	L.	=	35.196 Imperial fluid ounces.
1 Decilitre	dl.	= 0.1	L.	=	3.5196 ,, ,,
1 Centilitre	cl.	= 0.01	L.	=	0.352 Imperial fluid ounce.
1 Millilitre (Mil)	ml.	= 0.001	L.	=	0.0352 ,, ,,
1 Decimil	dml.	= 0.0001	L.		1.689 Imperial minims
1 Centimil	cml.	= 0.00001	L.	=	0.169 Imperial minim.

For all ordinary purposes of calculation, the cubic centimetre may be taken as equivalent to the millilitre, the exact relation being as 1 : 0.99984. These, which are the smallest measures of capacity commonly used, are too large for expressing conveniently the smallest doses prescribed. The Board of Trade, therefore, has authorised the use of the term Mil for the millilitre, and has further authorised two sub-divisions of this measure, the Decimil and Centimil. Thus the objection, urged by some, that the metric system has no measures suitable for prescribing and dispensing purposes, is obviated. Glass measures with these graduations can now be obtained.

For a comparison of the values of some of the more frequently employed expressions of the two systems, the following may be found convenient for reference :—

Length—

1 mm. (millimetre)=1/25 of an inch.

1 cm. (centimetre)=2/5 of an inch.

1 inch=25.4 millimetres or 2½ centimetres.

Mass—

1 mgm. (milligram)=0.01543 grain (or approx. 1/64 grain).

1 gm. (gramme)=15.4323 grains.

1 kgm. (" kilo " or kilogram)=2lb. 3¼ oz. avoirdupois.

1 pound avoirdupois=453.592 grammes.

1 ounce avoirdupois=28.35 grammes.

1 grain=0.0648 gramme or 64.8 milligrams.

Capacity—

1 centimil=0.17 minims (approx.) Imperial measure.

1 decimil=1.7 minims (approx.) Imperial measure.

1 c. c. (cubic centimetre) (or 1 mil)=16.9 minims, Imperial measure.

1 L. (litre)=35.196 fluid ounces (35 fl. oz., 1 fl. dr., 34 min.), Imperial measure.

1 fl. ounce, Imperial measure=28.42 cubic centimetres.

1 pint, Imperial measure=568.34 cubic centimetres.

1 gallon, Imperial measure=4.546 litres, or 10 lb. avoirdupois of pure water at 62°F., and under an atmospheric pressure of 30 inches of mercury.

FACTORS FOR CONVERTING FROM ONE SCALE TO THE OTHER.

To convert grammes into grains	×	15.48
,, ,, ,, ounces, avoirdupois	×	0.03527
,, kilograms into pounds	×	2.2046
,, grains into grammes	×	0.0648
,, avoirdupois ounces into grammes	×	28.35
,, troy ounces into grammes	×	31.104
,, cubic centimetres into fluid ounces, Imperial	×	0.0352
,, litres into fluid ounces, Imperial	×	35.2
,, fluid ounces into cubic centimetres	×	28.42
,, pints into litres	×	0.568
,, metres into inches	×	39.37
,, inches into metres	×	0.0254

THERMOMETERS.

Fahrenheit, Centigrade and Reaumur.

This table shows the relationship between these three thermometric scales at certain temperatures.

F.	C.	R.	F.	C.	R.
212	100	80	95	35	28
200	93.3	74.7	94	34.4	27.6
150	65.6	52.4	92	33.3	26.7
112	44.4	35.5	90	32.2	25.8
110	43.3	34.7	88	31.1	24.9
108	42.2	33.8	86	30	24
106	41.1	32.9	84	28.9	23.1
105	40.6	32.4	82	27.8	22.2
104	40	32	80	26.7	21.3
103	39.4	31.6	78	25.6	20.4
102	28.9	31.1	76	24.4	19.6
101.5	38.6	30.9	74	23.3	18.7
101	38.3	30.7	72	22.2	17.8
F.	C.	R.	F.	C.	R.
100.5	38.1	30.4	70	21.1	16.9
100	37.8	30.2	68	20	16
99.5	37.5	30	66	18.9	15.1
99	37.2	29.8	64	17.8	14.2
98.4 Body temperature	36.9	29.5	62	16.7	13.3
			60	15.6	12.4
98	36.7	29.3	58	14.4	11.6
97.5	36.4	29.1	56	13.3	10.7
97	36.1	28.9	54	12.2	9.8
96.5	35.8	28.7	52	11.1	8.9
96	35.6	28.4	32	0	0
95.5	35.3	28.2			

Square or Land Measure.

144 sq. inches	=	one sq. foot.
9 ,, feet	=	,, ,, yard.
30¼ ,, yards	=	,, rod, pole or perch.
16 rods	=	,, chain.
40 ,,	=	,, rood.
4 roods	=	,, acre.

Avoirdupois Weight.

16 drachms	=	one ounce.
16 ounces	=	,, pound.
14 pounds	=	,, stone.
28 ,,	=	,, quarter.
4 quarters	=	,, hundredweight.
20 hundredweight	=	,, ton.

Circular Measure.

Diameter of a circle	×	3.1416	=	Circumference.
,, squared	×	.7854	=	area of circle.
,, ,,	×	3.1416	=	surface of sphere.
,, cubed	×	.5236		solidity of sphere.

Water.

20 ounces	=	one pint.
One cubic inch	=	.0361 lb. = .58 oz.
,, gallon	=	10 lbs.
,, cubic foot	=	6.23 gallons.
35.943 C. feet.	=	one ton.

Rough Comparisons.

10 centimetres	=	4 inches.
1 litre	=	1¾ pints.
1 kilogram	=	2¼ lbs.
1,000 kilograms	=	1 ton.
1 square metre	=	10 sq. feet.
8 kilometres	=	5 miles.

APPENDIX A.

DISTRIBUTION OF VITAMINS IN FOODSTUFFS.

In this table 0 signifies that the vitamin has been tested for and not found, + that the material contains the vitamin, ++ that it is a good source of the vitamin and +++ that it is a rich source of the vitamin. The values entered under the heading vitamin B refer to the complex 'water-soluble B', entries being made under vitamins B_1 and B_2 when these have been separately estimated. (*Medical Research Council* 1932.)

Foodstuffs.	A	D	E	B1	B2	B	C
Oils and fats.—							
Cotton-seed hardened	0	..	+	..	..	..	..
Mustard-seed oil ..	..	..	0	..	..	0	0
Olive oil	0 to +	0 to +	+	..	..	0	0
Palm oil	+ to ++	0 to +	++	..	..	..	..
Pea-nut oil (Arachis oil)	0 to +	0	+	..	..	0	0
Soy-bean oil ..	0 to +	..	..	..	..	..	..
Whale oil	+ to ++	..	..	..	..	..	..
Wheat germ oil ..	+	..	+++ (very rich)	..	..	..	..
Ghee (Indian Butter fat)	0 to +	..	..	..	..	..	..
Butter fat	+ +	+ +	+ +	..	..	..	0
Lard	0 to +	0	0	..	..	..	0
Margarine, animal ..	0 to +	0 to +	..	..	..	..	..
,, vegetable	0	..	..	..	..	0	0
Mutton fat ..	+	..	+	..	..	0	0
Beef fat	+ +	+	..	..	..	0	..
Almond Oil ..	0	..	0	..	..	..	..
Cocoa butter ..	0	0 to +	0	..	..	..	..
Coco-nut oil ..	0 to +	..	+	..	..	0	0
Cotton-seed oil ..	0 to +	+	+	..	..	0	0
Fish-body oils.—							
Cod	+	..	..	..	..	..	..
Salmon	+ to + +	..	..	..	..	..	..
Sardine	0	..	..	..	..	..	..
Fish-liver oils.—							
Cod	+ + +	+ + +	0 to +	..	..	..	..
Halibut	+ + +	..	..	..	..	..	..
Cereals.—							
Barley, husked ..	..	..	..	+ +	..	..	0
Bread, wheaten, white, milk ..	+	..	..	..	..	..	0 to +
Maize, white, whole grain	0	..	..	+ +	+	..	0
Rice, bran	..	..	..	+ +	..	..	0
,, embryo ..	..	..	..	+ + +	..	..	0
,, parboiled, whole ..	..	..	..	+ +	..	..	..
,, parboiled, polished	..	..	..	+ +	..	..	..
Wheat, embryo ..	+ +	..	+ + +	+ + +	+ +	..	0
,, flour, whole meal	0 to +	..	..	+	+	..	0
Beans, haricot ..	..	..	..	+ +	..	..	0
,, mung. ..	+	..	..	..	..	+ +	..
Lentils	+	..	..	+ +	..	+ +	just +
Peas, green ..	+ +	..	..	..	..	+ +	+ + +
Soy beans	+	..	+	+	+	+	0
Nuts.—							
Almond	+	..	..	+	..	+	..
Chestnut	..	..	..	+	..	+	..
Coco-nut	+	..	..	..	..	+	..
Walnut, black ..	..	..	..	..	..	+	..
Vegetables.—							
Beet, root	0 to +	..	..	..	..	+	+
Cabbage, cooked ..	+	..	..	..	..	..	+
Carrot, cooked ..	..	..	..	..	..	..	+
Cauliflower, cooked ..	..	..	..	..	..	+	+ +

Foodstuffs.	A	D	E	B1	B2	B	C
Vegetables—*contd.*							
Celery, leaf, green ..	+ +	..	..	..	..	..	..
Cucumber	0 to +	..	..	..	..	..	+ +
Lettuce, green ..	+ +	..	+ + +	+ +	+	..	+ + +
Onion	0 to +	..	..	+	+	..	+ to + +
Potato, cooked ..	+	..	..	..	..	..	+ to + +
,, raw ..	+	..	..	+ +	+	..	+ + to + + +
,, peel ..	..	..	..	+ +	..	..	..
Radish	0 to +	..	..	..	..	+	+ +
Spinach, cooked ..	+ +	..	..	+	+ +	..	+ to + +
,, raw ..	+ +	0 to +	..	+	+ +	..	+ + 0 to + + +
Fruits.—							
Apple	+	..	..	+	+	+	+ to + +
Apricot	..	..	..	..	..	..	0 to +
Banana	+ to + +	low	+ +	+	+	..	+ +
Breadfruit	+ +	..	..	..	..	+	..
Custard apple ..	0	..	..	..	..	..	..
Date	+	..	..	+	..	..	..
Fig	+	..	..	..	..	..	..
Grape	+	..	..	..	..	..	very low
,, fruit ..	+	..	..	..	..	+	+ + +
,, ,, juice ..	+	..	..	..	..	..	+ + +
Lemon	+	..	..	..	..	+	+ + +
juice ..	+	..	..	..	..	+	+ + +
Lime	0	..	..	..	..	..	+ +
,, juice	0	..	..	+	..	..	+ +
Mango, ripe ..	+ +	..	..	..	..	..	+ + to + + +
Orange, pulp ..	..	..	..	+ +	+	+	..
,, juice ..	+	..	+	..	..	+	+ + +
Pear	..	..	..	..	..	+	+
Pineapple	+ +	..	..	..	..	..	+ +
Strawberry ..	+	..	..	..	..	+	+ to + + +
Tomato, ripe ..	+ +	..	..	+	+	+ +	+ + +
Meat and fish.—							
Bacon	0 to +	..	..	..	..	..	..
Beef	..	..	+ +	+ +	+ +	..	0 to +
Fish, fat, muscle ..	+	+	..	..	..	..	..
,, roe	+ +	..	..	+	..	..	..
Ham	0 to +	..	..	+	+	..	..
Mutton	..	..	..	+ +	+ +	..	0 to +
Oysters	+ +	+ +	..	..	..	+ +	+
Pork	0 to +	..	..	+ +	+ +	..	0 to +
Eggs,—							
Hen	+ +	+ +	..	+	+ to + +	..	..
,, yolk ..	+ +	+ + +	+ +	+ +	+	..	0
,, white ..	0	0	..	..	+ +	..	0
Milk and milk Products.—							
Cream	+ to + +	+	..	..	..	+ +	0 to +
Buttermilk ..	+	..	..	..	..	+	0 to +
Cheese, cheddar ..	+ +	..	..	0	+	..	..
Cow's milk, fresh ..	+ (varies)	0 to + (varies)	+ (varies)	+	+ +	..	+
Cow's milk, condensed	+ + (varies)	..	..	..	..	..	..
Cow's milk, dried ..	+ + (varies)	0 to + + (varies)	+ (varies)	..	..	+ +	0 to +
Cow's milk, pasteurized	+ (varies)	..	..	..	..	+	+
Cow's milk, sterilized	+ .. (varies)	..	..	..	..	+	0 to +
Goat's milk ..	+	..	..	..	..	+	+
Human milk ..	+	0 to +	..	+	+	..	0 to +

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